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ABSTRACT

This student manual and accompanying teachers' guide for senior high school science provide an in-depth study of a community-how it was established and developed. It emphasizes the environmental changes which have occurred through the use and management of its natural resources. A series of experiments in numerous areas provides students an opportunity to investigate the causes for change. Each experiment indicates the materials needed, the procedure to follow, and asks questions to help interpret the results. The teachers' manual also includes suggestions regarding preparation for the experiment, procedures, expected results, responses to interpretation questions, assessment tasks, and acceptable responses for the tasks. Fifty-three objectives serve to evaluate the degree of understanding achieved by the student. (BL)

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EVERYMAN'S PROBLEM

AN INSTRUCTIONAL UNIT FOR SENIOR HIGH SCHOOL SCIENCE

Board of Education of Baltimore County
1970

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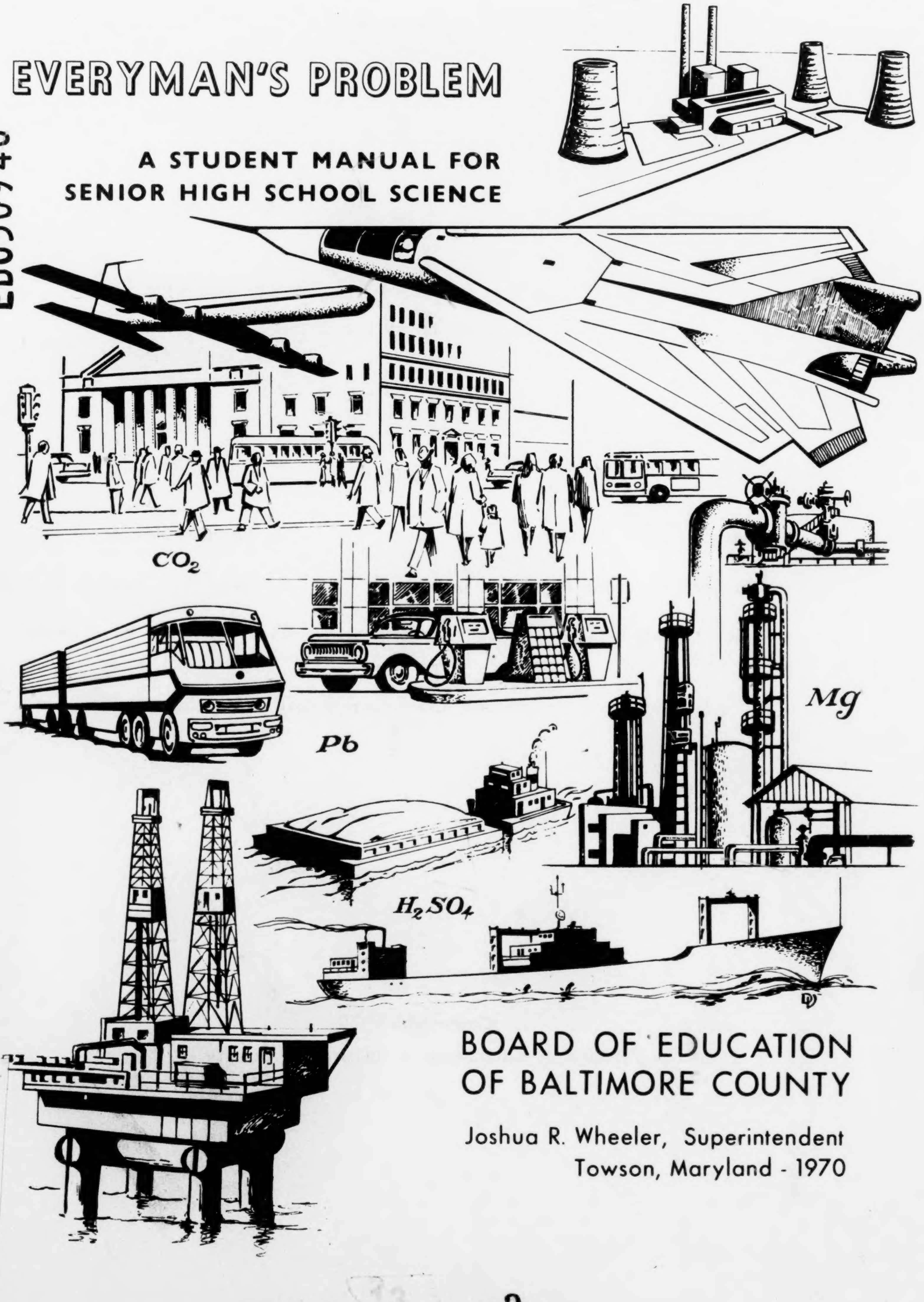
EVERYMAN'S PROBLEM

A STUDENT MANUAL FOR SENIOR HIGH SCHOOL SCIENCE



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THE NEWBURG STORY

This is a NOW unit. It deals with happenings in the real world. Pollution is a REAL thing that is happening NOW. It must be reduced if you are to survive.

PROCEDURE

Read The Newburg Story. As you read, pick out two sets of phrases; one set to describe the original farmland and the second set to describe the polluted Newburg community. Write the phrases in the chart on Page 3.

THE NEWBURG STORY

Once upon a time - now this isn't a make-believe story! It's a true story that has happened, is happening, and will continue to happen many times. You've seen all the acts in the story, but you probably haven't seen them in their proper order. So to get these acts in sequence, we have to begin in the past.

Once upon a time, a farmer had a 250-acre farm. On 200 acres he grew wheat, tomatoes, and corn. On the remaining 50 acres he had a thick woods, a lake, and a meadow.

Let's call the farmer Timothy Parker. Mr. Parker had four children: Mary, Louise, Tom, and Bill. All of the children swam in the lake. Tom and Bill fished whenever they weren't helping Dad on the farm. Sometimes the boys even caught enough sunnies and bass to have a really good fish fry. In the fall, when there was a chill in the air, the boys hunted. The gun shot blast would rend the stillness of the autumn air as a squirrel or rabbit was stopped by the shot.

Eventually, as always happens, the children became men and women and moved away from the farm. The farmer and his wife were now too old to work the land and they wanted some smaller living quarters.

One day a developer visited the home and offered what, to the farmer, appeared to be a fortune for the land. And so the farmer and his wife sold their 250 acres, moved to the city, and settled back to a life of ease and rest.

The developer lost no time in sending his bulldozers to prepare the land for a housing development. He sent out hand-bills, posted road-signs, and bought quarter pages in the newspaper saying:

> COME TO NEWBURG
>
> The Community of
>
> Lake Living, Boating, Fishing, Swimming

And so Newburg came to be "The Land of Lake Living." People fished, boated, and swam in the lake. They competed with each other for bigger and bigger boats, which they kept sparkling with the most televised detergents. They kept their homes spotless with the same detergents. They even polished themselves by bathing with the same detergents, because they found they didn't have a bathtub ring to scrub out if they used them. They also fertilized their beautifully mown lawns and kept them well watered. In short, they were doing all of the things the affluent middle-class does to keep the affluent middle-class look.

Years passed - only a few, maybe five or six - and Newburg began to show changes. The first change that became apparent was that the children began to complain that they weren't catching fish. Several fathers tried to prove that their offspring just didn't have the old know-how. But even they had to admit defeat. The fish became more and more scarce.

Sometime later another rumble ran through the community. All of the boatmen were raising a hue and cry. They couldn't go out on the lake for any distance before the motors of the boats were fouled with water-weeds. The men tried many methods for fighting the weed; cutting it by hand with a scythe and using weed killers. But the weeds just grew and grew until boating became a chore.

Then, almost overnight, in the middle of a hot August the lake became murky and a foul odor spread from the lake throughout the community. Day by day, the edges of the lake developed a brown, threadless embroidery that here and there bore bubbles which, as they broke, spit forth a stench. And, as the odor increased, the inhabitants of Newburg grew more and more vocal, "What's happened to our lake?", "Where are our fish?", "Why is our lake a murky mess?", "Why such a smell?", "What are the problems?", "What can we do?"

COMPARISON OF ORIGINAL FARM AND NEWBURG COMMUNITY

Farm Area	Newburg Community

BETTER HOMES AND GARDENS

In the years before the establishment of the town of Newburg, the farm produced abundant crops of tomatoes, wheat, and corn. To replace the necessary soil materials, crops were rotated. Manure from the farm animals was returned to the land. No chemical fertilizers were used. By contrast, the grass lawns of the new residents of Newburg do not thrive without the addition of commercial fertilizers rich in nitrates and phosphates. Although much of the fertilizer is absorbed by the grass, a large part of it is unused. What happens to it?

MATERIALS

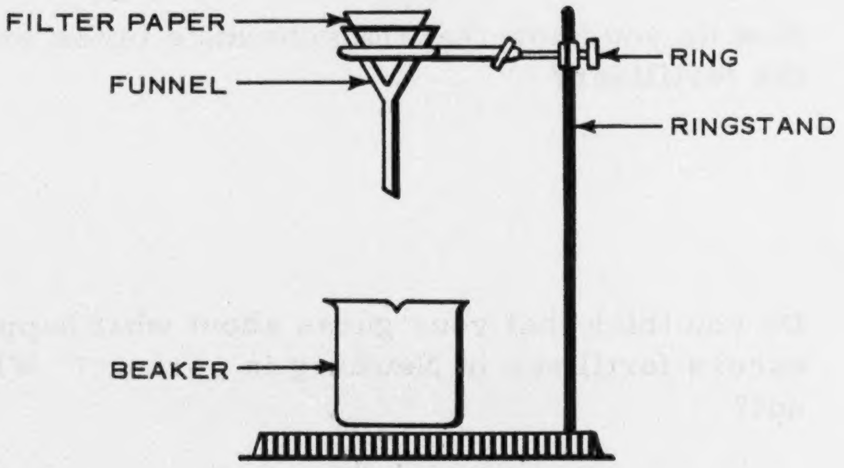
diagram of Newburg
soil, (fertilizer added)
beakers, 50 ml, 3
filter paper
funnel
ring with stand
heat sources
watch glass

PROCEDURE

1. Study the diagram of Newburg. What may happen to the fertilizer not absorbed by the grass?

2. Place your sample of Newburg soil into a beaker. Add water until the beaker is half-full. Mix the soil and water together by pouring the muddy water back and forth between two beakers several times.

3. Line the funnel with filter paper. Set up the funnel with the paper as shown in the diagram below.



4. Pour some of the muddy water in the funnel. As the filtered water drops into the beaker, add more muddy water to the funnel. Continue adding muddy water until you have collected clear liquid to a depth of about 1 cm.

5. Use a burner to heat the clear liquid until there is only about 0.5 cm left.

6. Pour a small volume of the clear liquid into a watch glass (enough to make a circle about 3 cm across). Set the watch glass aside until the water evaporates.

7. Describe the substance remaining in your watch glass.

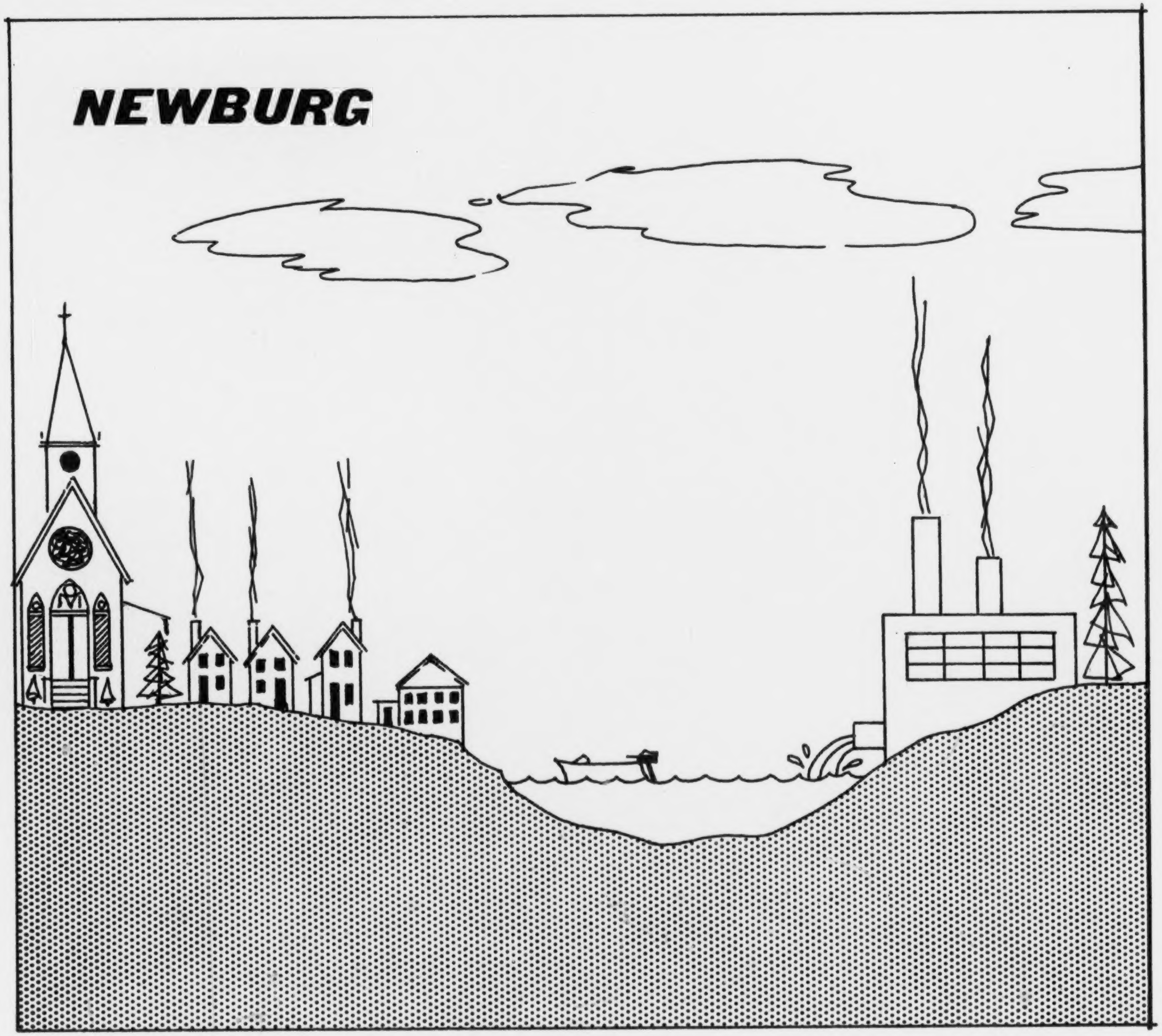
8. Compare the substance in your watch glass with each of the controls.

INTERPRETATION

1. Where did the substance in your watch glass come from?

2. How do you know that the substance in the watch glass is the fertilizer?

3. Do you think that your guess about what happens to the excess fertilizer in Newburg is correct? Why, or why not?


NEWBURG

THICKER THAN WATER

Lake Newburg has never been known to overflow its banks. How has the volume of water managed to remain the same throughout the years? Have the amounts of dissolved minerals washed into the lake also remained the same?

MATERIALS

beaker, 100 ml
balance
salt, 10 g
stirring rod
heat source
ring stand and ring
asbestos pad

PROCEDURE

1. An easy method to weigh the salt needed for this experiment is as follows:
    a. Weigh a clean, dry 100-ml beaker.
    b. Leave the beaker on the balance and adjust the weights to add 10 g to the righthand side. This throws the balance off.
    c. Now add salt to the beaker until balance is once again achieved.

        What is the weight of the beaker plus the salt? __________________g

        What is the weight of the salt added? __________________g

2. Now add just enough water (a depth of 2 or 3 cm) to dissolve all of the salt. Stir while adding the water.
3. Evaporate most of the water from the salt solution by heating.

    CAUTION: Stop heating while the bottom of the beaker still has a thin layer of water in it.

    Set the beaker aside overnight.

4. When the beaker is completely dry, weigh it with its contents. What is the weight of beaker and contents after water was evaporated? __________________g

INTERPRETATION

1. How does the weight of the salt after evaporation compare to the weight of the salt before evaporation?

2. When the water evaporated, what happened to the substance (salt) that was dissolved in the water?

3. Suppose that without cleaning the beaker, you were to add 10 more g of salt to it, add more water, and then evaporate again. At the end of this procedure what would the new weight of salt be? Why would this be so?

4. What normally supplies the heat necessary to cause evaporation of water from lakes?

5. Dissolved substances have washed into Lake Newburg over the years. What do you think has happened to the concentration of these substances in the lake? Explain.

6. In applying the results of this investigation to the Lake Newburg problem, what major assumption must you make?

7. What effect do you think the substances leached from the lawns and gardens of Newburg would have on the plants growing in the lake?

E-4

A LAKE CHANGES COLOR

When Newburg residents fertilized their lawns and vegetable gardens, they spread the "plant food" generously. Like all human beings, they were in a hurry to see green growth and reap their bounteous crops. Each spring the ritual of spreading the fertilizer was observed by each home owner in Newburg.

Each year not only the lawns became greener - so did the lake! One summer the weeds were so thick that the boat motors became fouled with tangled green mats. At the same time, the fishing became less and less productive. It was rare when a family had a dinner of fresh lake trout. And each fall the waters of the lake developed a disgusting stench.

MATERIALS

masking tape
beaker, 500 ml, 5
plant food tablet, 2
beaker, 1000 ml
stirring rod
pipette, 5 ml
alcohol
beaker, 100 ml, 2
balance
filamentous algae
tweezers

PROCEDURE

1. Use masking tape to make four labels. On one label write, "No Fertilizer"; on the second label write "5 ml Fertilizer"; on the third label write "10 ml Fertilizer"; and on the fourth label write "15 ml Fertilizer." Place one label on each of four 500 ml beakers.

2. Put 500 ml of tap water in each of the four beakers.

3. Crush one plant food tablet and dissolve it as thoroughly as possible in 1000 ml of tap water.

4. Add this solution to the labeled beakers in the amounts indicated by their labels.

5. a. Weigh an empty 500 ml beaker.

   b. Gently blot a mass of algae on a paper towel to remove the excess water.

c. Using tweezers, weigh 10 g of algae. Hint: Use the weighing method practiced in Investigation 3, Procedure Steps 1 and 2.

d. Shake the weighed algae from the empty beaker into one of the four beakers containing fertilizer solution.

6. Repeat b, c, and d of Procedure Step 5 for each of the remaining beakers containing fertilizer solution.

7. Place the four beakers in a sunny window, and leave for at least two weeks. Be sure the temperature does not vary greatly from day to day.

8. At the end of two weeks, examine the four beakers carefully. Where are the algae growing - at the top, middle, or bottom of the beaker?

9. Weigh the algae using the procedure established in Procedure Step 5. Complete the chart below:

Beaker	Beginning Wgt. of Algae	Final Wgt. of Algae
No fertilizer	10 g	
5 ml fertilizer	10 g	
10 ml fertilizer	10 g	
15 ml fertilizer	10 g	

INTERPRETATION

1. What effect did the fertilizer have on the growth of the algae?

2. How does this experiment relate to the conditions that developed in Lake Newburg?

3. The surface of a lake is in contact with the air; therefore, lake water receives oxygen through the surface. Knowing this, what effect do you think a mat of algae might have on the oxygen supply of a lake?

4. By day, algae and other green water plants give off oxygen. At night they not only cease giving off oxygen, they actually use it up. When would a large growth of algae most critically affect lake animal life?

5. Fish and other lake animals are rich in carbon, hydrogen, oxygen, and nitrogen. Why would dead fish help increase the amount of algae in a lake?

6. In summer there are many hours of sunlight. In fall the number of daylight hours become less and less. What do you predict will happen to the lake full of algae when fall comes? Explain your prediction.

7. Using the information developed in this and the preceding investigations, explain the events that occurred in Lake Newburg.

E-5

FISH IN A BOWL

DANGER
POLLUTED
WATER

The Newburg Supermarket has long shelves of soaps and detergents and the stockboys are always busy replenishing the supplies. The people of Newburg pride themselves on neatness and cleanliness, so they buy large quantities of these products. Most of us like to be clean. But what price must we pay for our cleanliness?

Detergents are composed of very stable molecules. The molecules do not easily break down and, unlike most kitchen and household wastes, they are not used as food by bacteria. Therefore, once in waste water they stay there and they concentrate there, just as do the fertilizers that you studied. Soaps are less of a problem. They are biodegradable; that is, bacteria break down the soap molecules to simpler substances.

After passing through individual home disposal systems the waste waters of Newburg percolate through the soil. The disposal systems are fairly efficient in removing harmful germs and solid wastes but not the detergents. When the water reappears in springs and streams, there are the detergents. What effects do they have?

MATERIALS

beakers, 400 ml, 2	small, live goldfish, 2
conditioned water, 200 ml	medicine dropper
graduated cylinder	liquid detergent

PROCEDURE

1. Add 200 ml of water to each of two clean beakers.

2. Into each beaker place one goldfish.

3. Use a medicine dropper to add one drop of detergent every 60 seconds to one beaker. Do not add detergent to the other beaker.

4. Have your partner record, in the chart below, any changes in the behavior and appearance of the fish. Pay particular attention to breathing rates and motions that you observe. Breathing is indicated by the opening and closing of the gill covers that mark the division between the head and the body of the fish.

Drops of Detergent Added	Fish in Detergent	Fish in Water with No Detergent
2		
4		
6		
8		
10		
12		
14		
16		
18		
20		

INTERPRETATION

1. How can you be certain that any change in appearance or behavior of the experimental fish is really caused by the detergent?

2. What is the term we use to describe the check which you have used to make sure that the differences were caused by the detergent?

3. Summarize the difference between the two fish in terms of appearance and behavior?

4. At what point did the fish show the most marked change in behavior?

5. Calculate the fraction of detergent in the water at the time when you first noticed a change.

$$\frac{\text{number of drops of detergent}}{\text{4000 (drops in 200 ml)}} =$$

6. What conclusions can you draw from your data?

7. How might this particular kind of pollution find its way into rivers, bays, and oceans?

8. If 3,000,000 families each use one pint of detergent per week, calculate the total amount used by all of the families in a year. Hint: There are 8 pints in one gallon.

Total ________________gallons

Show calculations here:

9. Water treatment plants cannot treat used water to remove detergents. Suggest ways in which we might stop this kind of pollution.

10. Suggest why detergent pollution has been difficult if not impossible to stop. Think carefully.

WHERE IS NEWBURG?

Where is Newburg? Is it near Baltimore? Is it in the South? The Mid-West? The West? Actually, as you may have guessed, Newburgs are everywhere. Newburg is really Chicago, or San Francisco, or Baltimore. Lake Newburg could be Lake Michigan or San Francisco Bay or our own Chesapeake Bay. For that matter, it could be the Atlantic or Pacific Oceans. In short, Newburg is America in miniature.

Are lawns thick and green in your neighborhood? No doubt your parents - and the school groundskeepers - have strewn the lawns with mysterious substances such as "5-10-15" or "7-20-10." These are merely mixtures of nitrogen, phosphorus, and potassium compounds, all of which are soluble in water. You have already discovered the consequences in Newburg. They are the same in Baltimore County.

You can do without lawns. But you cannot do without farms - somewhere, if not in your own neighborhood. In 1969 alone, farmers added over 6,000,000 tons of fertilizer to the land. In your lifetime, the population of the United States will increase from 200 million to 300 million, an increase of 50 per cent. Logically, more people need more food, and to increase food production more chemical fertilizer is going to be used.

What a dilemma! People need plants; plants need fertilizing chemical compounds. If people don't provide them, the plants don't grow well enough to feed the population. If people do provide these substances, large amounts are leached out of the soil. And this is just the beginning of the pollution problem.

Meanwhile, back to Baltimore County.

MATERIALS

diagram of Lake Newburg
map of Baltimore County
overhead projector

PROCEDURE

1. Refer to the diagram of Lake Newburg. Show by the use of arrows how:

    a. nitrates and phosphates get into Lake Newburg.

    b. water leaves the lake through evaporation.

    c. evaporated water falls over the town again.

2. Refer to the map of Baltimore County.

   a. Find the approximate location of your home. Mark it with an "X."

   b. Are there any bodies of water near your home? If so, which ones?

   c. Trace on the map the possible path of drainage from your home into the nearest body of water.

   d. Where does the body of water nearest your home flow?

   e. There are many farms located in northern Baltimore County. Trace on the map the possible paths of drainage from this location into the Chesapeake Bay.

   f. Most of the county's heavy industries are located in the southeast. What river or rivers would they most likely pollute? Where do these rivers lead?

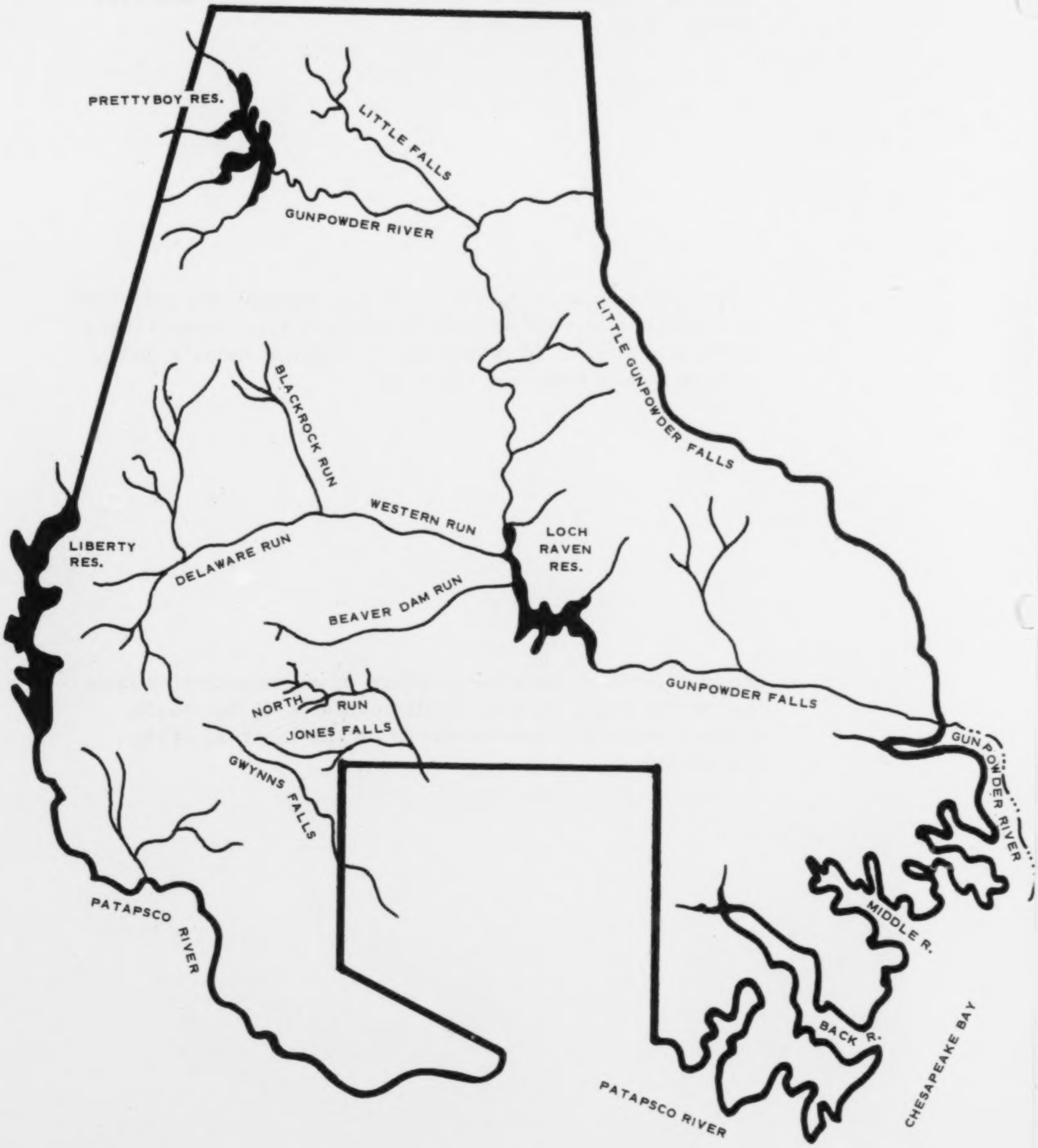
INTERPRETATION

1. Some insecticides, such as DDT, resemble detergents in being very stable. DDT has been found in water fowl in Anarctica, far from any place where DDT has been used. Explain how DDT could have traveled so far.

2. The welfare of the Chesapeake Bay must finally depend upon the cooperation of many cities, counties, and even states. Why is this so?

3. The oceans have long been used as "dumps" for pollution on the assumption that their enormous size would safely dilute any amount of material. In light of today's world what is wrong with this thinking?

4. Many scientists urge the passage of water pollution laws that would apply equally to all countries of the world. Explain why such laws would be in the interest of the United States.


PRETTYBOY RES.
LITTLE FALLS
GUNPOWDER RIVER
LITTLE GUNPOWDER FALLS
BLACKROCK RUN
WESTERN RUN
LIBERTY RES.
DELAWARE RUN
LOCH RAVEN RES.
BEAVER DAM RUN
GUNPOWDER FALLS
NORTH RUN
JONES FALLS
GWYNNS FALLS
GUNPOWDER RIVER
MIDDLE R.
PATAPSCO RIVER
BACK R.
CHESAPEAKE BAY
PATAPSCO RIVER

E-7

DILUTE AND POLLUTE

Detergents are not the only pollutants that are sent from Newburg's homes each day. On an average each Newburg resident uses close to 100 gallons of clean water per day - as do all the rest of us Americans. This water leaves homes carrying solid and liquid wastes from our tubs, sinks, and toilets.

Sewage consists of approximately 99.9 per cent water and 0.1 per cent suspended particles. On a percentage basis, this amount of solids appears very small, only one-thousandth of the total. However, the daily amount of these solids from a large city such as Baltimore is more than 100 tons.

In Newburg, as in hundreds of other American communities, sewage from each house flows to an individual septic tank. Sooner or later this fills up and, if not attended to, overflows. In most large cities, sewage is carried underground through a system of pipes to treatment plants. Here the solids are separated from the water, and both solids and water are treated to prevent epidemics of disease.

Many small communities, however, lack treatment plants. From them and from improperly used septic tanks much untreated (raw) or poorly treated sewage finds its way into streams, lakes, and estuaries.

What are the effects of raw sewage in bodies of water?

Part A

MATERIALS

- clean water, 100 ml
- raw sewage, 100 ml
- beakers, 250 ml, 2
- microscope
- microscope slides, 2
- cover slips, 2

PROCEDURE

1. Place 100 ml of clean water into a beaker and 100 ml of raw sewage into another beaker.

2. Examine each container. Record observations in the following chart:

	Clean Water	Raw Sewage
Appearance (cloudiness, bubbles, scum)		
Odor		

3. Add one drop of the clean water to the middle of a clean microscope slide. Cover the drop with a cover slip. Using both high and low magnification, observe and record what you see.

4. Repeat Procedure Step 3, using one drop of the raw sewage.

INTERPRETATION

1. As far as you are able to determine, what caused the differences in appearance and smell between the polluted and unpolluted water?

2. Why is it considered dangerous to swim in or drink water containing raw sewage?

3. Most bacteria use oxygen. What do you think would be the amount of oxygen in water polluted by raw sewage compared to unpolluted water? Give reasons for your answer.

Part B

You have already guessed what effect bacteria have on the amount of oxygen dissolved in water. To test for the amount of oxygen in water we use the Winkler method that follows:

MATERIALS

clean water, 100 ml
raw sewage, 100 ml
graduated cylinder, 100 ml
erlenmyer flasks, 250 ml, 2
eye dropper
stirring rods, 2
Solution A
Solution B
sulfuric acid
starch solution
Solution C

PROCEDURE

1. Add 100 ml of clean water to one flask. Add the same amount of polluted water to another flask.

2. Add 10 drops of Solution A to each flask.

3. Now add 30 drops of Solution B to each flask. Notice how cloudy the contents of the flasks become.

4. Shake both solutions gently.

5. Now have your teacher add concentrated sulfuric acid, one drop at a time, to each flask until the cloudiness disappears. Swirl the contents of each flask gently. The color of the contents is a rough indication of the amount of oxygen. The darker the color, the more oxygen.

CAUTION: Concentrated acid is very dangerous! Be careful.

6. Now add starch solution one drop at a time to each flask until the contents turn dark blue. Swirl while adding the starch.

7. The final step in comparing the amounts of oxygen in the clean water and the raw sewage must be done very carefully. Add Solution C to the beaker containing clean water a drop at a time. Continue adding Solution C, swirling and counting the drops as you do so, until the contents of the beaker become clear. Record the number of drops of Solution C.

   clean water: __________drops

8. Repeat Step 7, adding Solution C to the flask containing raw sewage.

   raw sewage: __________drops

9. Solution C takes up oxygen; this results in the clearing of the contents of the flasks. Which sample, clean water or raw sewage, contained the most oxygen? On what do you base your answer?

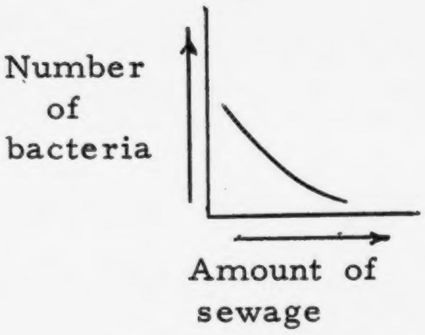
INTERPRETATION

1. The lower parts of the Patapsco River have very little dissolved oxygen. What might you suspect about this river?

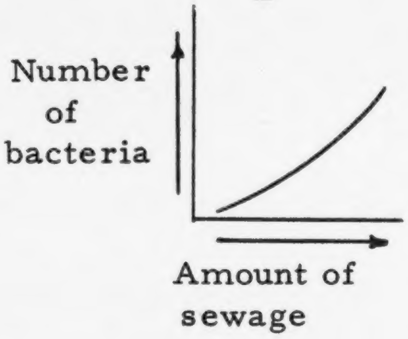
2. Water being treated at a sewage plant is sprayed into the air. Why do you think this step is taken?

3. Which graph best shows the relationship between the amount of sewage and the number of bacteria in water?

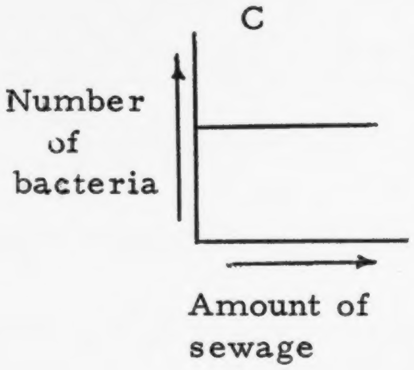
A



B

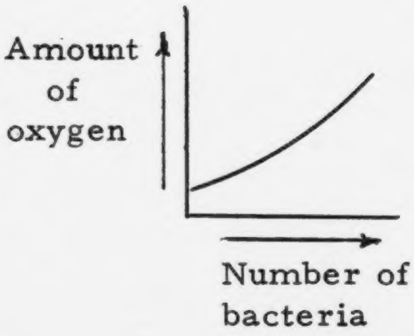


C

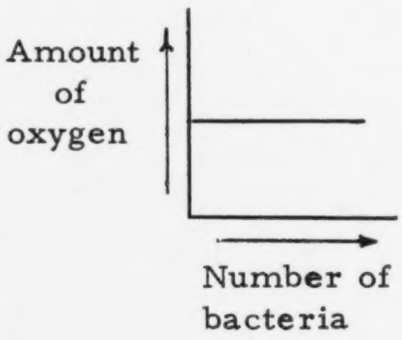


4. Which graph shows the relationship between bacteria and oxygen?

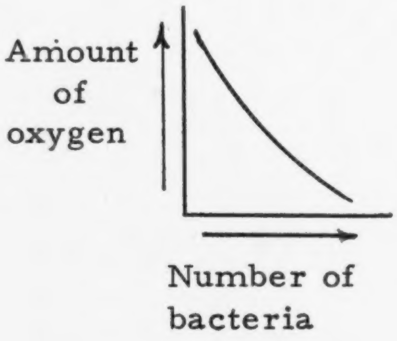
A



B



C



5. Summarize the reasons for considering pollution of water by untreated sewage as undesirable.

WARM UP

Lake Newburg was a big attraction to the people who bought home sites near it. An area of open water is an attraction to many people. To the people of Baltimore County the Chesapeake Bay is an attraction. Lake Newburg has its problems, but it is too small to have many problems that are serious in larger bodies of water.

The Chesapeake Bay is many things to many people. To the waterman it is a livelihood of $65,000,000 worth of shellfish and finfish per year. To the person seeking recreation, it is a place for boating, gunning, swimming, skiing, and just plain loafing. To the manufacturer and shipper, it is a water highway over which 110 million tons of goods are carried each year. To the geographer, it is 22% of the total area of Maryland. To the land developer, it is about 3000 miles of shoreline. And to the power engineer, it is a means of saving $200 million a year in the cost of cooling electrical generators.

In the process of generating electricity, large amounts of heat are produced. To maintain the generating machine the heat must be removed. The quickest, cheapest, and most convenient way to carry away the heat is to use moving water. This, however, results in the newest threat to the life of the Chesapeake Bay and many other bodies of water throughout the country: thermal (heat) pollution.

Part A

MATERIALS

test tubes, large, 2
cold water
test tube holder
burner
test tube tongs

PROCEDURE

1. Half fill each of two large test tubes with cold water.
2. Using an alcohol lamp or a bunsen burner, slowly and gently heat the bottom of one of the tubes. Hold the tube on a slight slant. Continue heating for several minutes, but do not allow the water to boil.

CAUTION: Do not point the tube toward anyone.

3. Look carefully at the sides of both the heated and the unheated tubes. What differences do you see?

4. Tap the bottom of the heated tube gently on the desk top. What happens?

INTERPRETATION

1. What happens to the gases in liquids as the temperature is raised?

2. Suggest a reason for the deaths of many living organisms near power plants.

Part B

The gas released from heated water might be one or more of a number of different kinds. Using the Winkler method, you can find out whether the gas released upon heating is oxygen.

MATERIALS

beakers, 250 ml, 2
water, hot and cold
graduated cylinder, 100 ml
medicine dropper
Solution A
Solution B
stirring rods, 2
sulfuric acid, concentrated
starch solution
Solution C

PROCEDURE

1. Measure 100 ml of cold water into one beaker. Measure 100 ml of heated water into a second beaker.

2. Add 10 drops of Solution A to each beaker.

3. Add 30 drops of Solution B to each beaker.

4. Using separate stirring rods for each beaker, stir both the hot and cold water solutions gently.

5. Have your teacher add concentrated sulfuric acid until the cloudiness disappears.

> CAUTION: Acid is extremely dangerous.
> Avoid any contact.

6. Add starch solution, one drop at a time, to both solutions and stir after each drop until both turn dark blue.

7. Using the medicine dropper, add Solution C, a drop at a time, to the cold water. Record the number of drops necessary to clear the water.

8. Repeat Step 7, adding Solution C to the heated water.

Cold water ____________ drops

Heated water ____________ drops

9. Which water had the most dissolved oxygen?

10. Which water had the least dissolved oxygen?

INTERPRETATION

1. Water has been boiled and allowed to cool to 18°C. A fish is placed in this water. Another fish is placed in unboiled water at 18°C. All other factors remaining the same, which fish has the better chance for survival? Why?

2. Some biologists predict a change in the kinds of fish in water near power plants. Explain how this can happen.

3. You have five containers of water at temperatures of 15°C, 10°C, 38°C, 18°C, 45°C. Order from the least amount of dissolved oxygen to the most.

1st ______(least), 2nd _______, 3rd _______, 4th _______

5th ______(most)

4. You have learned that heavy growth of algae has many undesirable effects. Algae live best in fairly warm water containing phosphates, which are abundant in sewage, fertilizers, and some detergents. From this information and what you have discovered in the laboratory, explain why algae are becoming more of a problem each year.

Part C

MATERIALS

Map of "Existing and Proposed Power Plants"

PROCEDURE

Refer to the map, "Existing and Proposed Power Plants." Using this map as a guide, answer the following questions:

1. In what ways or way are the locations of the power plants similar?

2. From the introductory paragraph of this investigation, give a logical reason for the locations picked for the plants.

3. Why are the Susequehanna, Patuxent, Potomac, York, and James Rivers important to the Chesapeake Bay?

4. Locate the Patuxent River on your map. Some strange things occurred shortly after the opening of the existing power plant on this river. What explanation can you give for the following group of events?

   a. A mysterious "kill" wiped out 40,000 blue crabs.

   b. A very large number of green (not fit to eat) oysters appeared.

   c. The feeding and spawning habits of certain fish, clams, and shrimp changed.

   d. A "kill" of rock bass occurred in the area.

   e. A change in the kind and amount of water plants was noted.

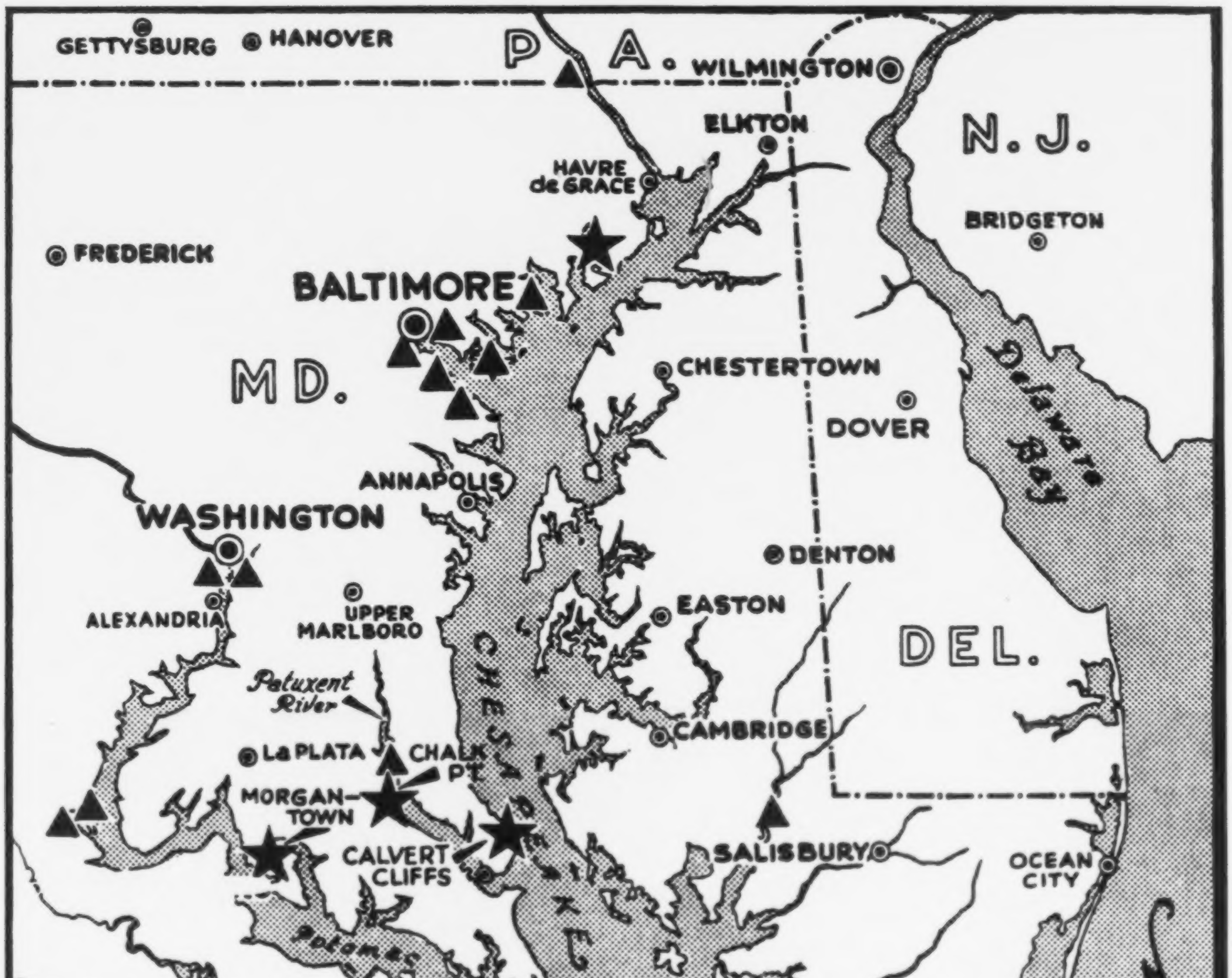
INTERPRETATION

1. In what ways could thermal pollution upset the economy of the State of Maryland?

2. In 1968, generating plants in the Chesapeake Bay region used 10% of the water that flows into the Bay each day. By 1975, they are expected to use 25%. By 1980, they are expected to be using 75%. Graph these figures below.

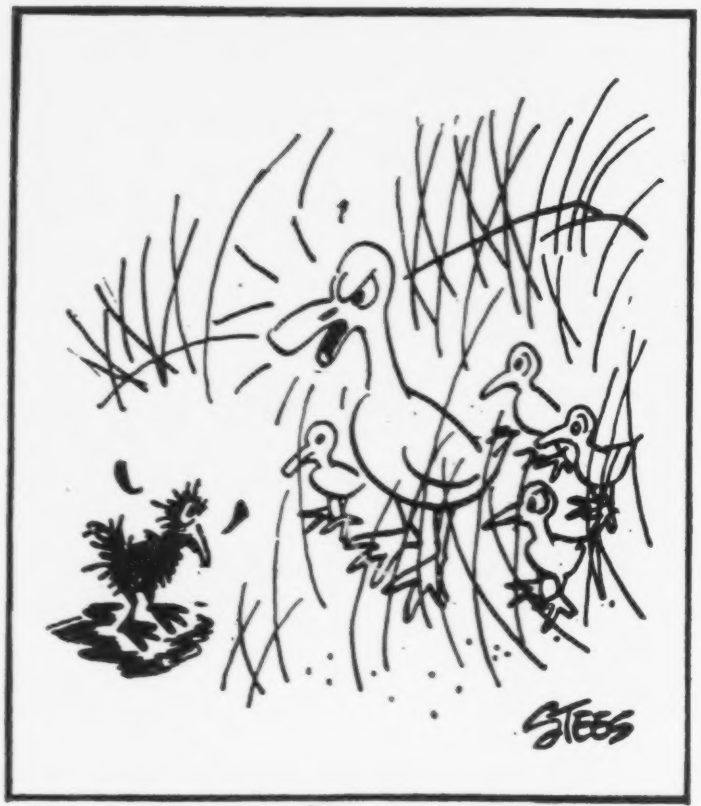
3. Scientists are not absolutely certain about all of the effects of thermal pollution or what the temperature increase will be in the future. Does this mean that this kind of pollution is safe? Why or why not?

EXISTING AND PROPOSED POWER PLANTS IN THE CHESAPEAKE BAY REGION


GETTYSBURG
HANOVER
P A.
WILMINGTON
ELKTON
N. J.
HAVRE de GRACE
BRIDGETON
FREDERICK
BALTIMORE
MD.
CHESTERTOWN
DOVER
Delaware Bay
ANNAPOLIS
WASHINGTON
DENTON
ALEXANDRIA
UPPER MARLBORO
EASTON
DEL.
Patuxent River
CHESAPEAKE
CAMBRIDGE
La PLATA
CHALK PT.
MORGANTOWN
CALVERT CLIFFS
SALISBURY
OCEAN CITY
Potomac River
TO LOUISA
Pt. Lookout
CRISFIELD
CHINCOTEAGUE
VA.
Rappahannock R.
BAY
ATLANTIC OCEAN
RICHMOND
York R.
James River
WILLIAMSBURG
Cape Charles
PETERSBURG
James R.
HOG I.
NEWPORT NEWS
Cape Henry
NORFOLK
PRESENT
PROPOSED 1967
0
10
20
30
SCALE OF MILES

E-9

SLICKER AND SICKER[1]



"ABERNATHY! YOU'VE BEEN SWIMMING IN THE OCEAN AGAIN."

Funny? Not really. In real life, Abernathy would be a dead duck. Like tens of thousands of other water birds, his feathers would become saturated with oil, destroying his natural buoyancy. He could neither float nor fly away. Finally, exhausted, he would drown.

At Lake Newburg only dribbles of oil from motorboats and an occasional spill at the marina disturb Abernathy's way of life. But on the larger waters of the world oil pollution has become a serious matter not only for ducks but for fish and oysters - and man.

Oil is absolutely essential to our way of life. It powers American's fleet of automobiles, and it also is a basic source of energy. Along with gas, it furnishes 75% of U.S. energy needs. Imagine a stack of barrels, each four feet high, reaching 10,000 miles into the sky! This is our daily consumption of oil. Your personal share of this is 12 quarts a day. Could you live without your 12 quarts of oil per day? Maybe, but not nearly as well.

Every year more oil is shipped over water. In 1969 over one billion tons (5 billion of our barrels) moved over water in ships carrying up to 300,000 tons each. In the process, over a million tons a year are spilled, leaked, or deliberately flushed into the sea. Still more oil leaks or spouts directly into the water from offshore wells, 7,500 of which now rim the United States. Hundreds of miles of beaches have been spoiled. Fish, waterfowl, and shell fish have been killed and their breeding grounds destroyed indefinitely.

What can we do about spilled oil? This is a serious question that demands a serious answer.

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[1] Cartoon reproduced with permission of the artist.

MATERIALS

beaker, 250 ml
motor oil
medicine droppers, 3
paper towels, 3
non-absorbent cotton
matches
forceps
straw
styrofoam, 2 small pieces
alcohol
detergent, 10 ml

Part A

PROCEDURE

1. Pour water into a beaker until it is about two-thirds full.

2. Add 20 drops of oil to the water.

3. What happens to the oil?

   Does any reaction occur between the water and the oil? If so, what?

4. How might you remove the oil from the water? Think carefully. Scientists have not yet solved this problem in a satisfactory way, so your ideas are as good as any! After you have given this some thought, list below all the ideas that have occurred to you.

5. Before proceeding with Part B, share your ideas with other members of your class.

Part B

Now you will try some methods that have been used to remove oil from water to determine how well they work. Keep alert for problems that might crop up if you were to use these methods in an actual ocean oil spill.

1. Try using the medicine dropper to remove the oil from the water surface. Describe your experience.
2. Try soaking the oil from the water with the paper towel. What happens?
3. Try soaking up the oil with non-absorbent cotton. What happens?
4. Touch a lighted match to the surface of the oil. Then lay the lighted match on the surface of the oil. What happens?
5. Tear 3 pieces of paper towel, each about 1 cm square. Using forceps, place the pieces on the surface of the oil. Remove the pieces carefully and place them on a paper towel.
6. Repeat Step 5, using several pieces of straw instead of paper. Place the straw on the paper towel with the small pieces of paper. Record the effectiveness of both the paper and the straw in removing oil.
7. Add another 10 drops of oil to the water. Place a small piece of styrofoam into the oil. Record the effect of the styrofoam on the oil.

8. Place a lighted match on the styrofoam. What happens?

9. Using forceps, push the piece of styrofoam to the bottom of the beaker. Then remove the styrofoam and place it on the paper towel. Using a new medicine dropper, place alcohol onto the oil in the beaker one drop at a time. What happens to the oil?

10. While looking through the side of the beaker, add detergent one drop at a time to the oil. Describe what you see.

INTERPRETATION

1. Now apply the methods you have used in the laboratory to the problem of cleaning up oil spills on the ocean. In the chart below list reasons why each method might work on the ocean or might not work.

Methods	Why This Might Work	Why This Might Not Work
1. Using eyedropper		
2. Removing with paper towel		
3. Using non-absorbent cotton		
4. Touching lighted match to oil		
5. Removing with small pieces of paper towel		
6. Removing with straw		
7. Removing with styrofoam		
8. Burning with styrofoam		
9. Adding alcohol		
10. Adding detergent		

2. Is oil more or less dense than water? How do you know?

3. Why doesn't oil burn easily? HINT: Think of the requirements for burning.

4. Straw and styrofoam are commonly used in cleaning up oil spills. Why?

5. Commercial oil dispersents, which have basically the same effect as detergents, are frequently used. Do such dispersents represent a good method for removing oil? Why or why not?

6. Why does burning oil off of the water surface not represent a good solution to the oil pollution problem?

7. Oil tends to stay in one puddle in water. Using this fact, suggest a method for cleaning up oil spills.

8. Some kinds of bacteria consume oil droplets as food. However, they cannot use oil in big blobs. Using these facts, suggest a method for preparing oil as bacteria food.

9. List regulations, rules, laws, etc., that might be useful in preventing pollution by oil slicks.

SOMETHING ABOUT GASES

As the population of Newburg increased, so did the number of automobiles. Now, morning and evening the main roads are clogged with commuters. During the day housewives, at their shopping, jockey for road space with truck drivers delivering the goods. The town council voted for a beltway, but the beltway seems to have increased traffic. And the blue haze of exhaust gases increases. What harm is in car exhaust? How can we collect exhaust to study it?

Part A

PROCEDURE

1. Observe the demonstration set up by your teacher. Describe the difference between the two bottles.

2. After bottles have remained in the room overnight, re-examine them.
    a. Describe any changes you observe in the set-up of the "warm" bottle.
    b. Describe any changes you observe in the set-up of the "cold" bottle.

INTERPRETATION

1. From your observations, what evidence indicates that gases dissolve in liquids?

2. Which liquid, the warm or the cold, retained more dissolved gas? Give evidence for your answer.

3. Complete the following sentence: The colder a liquid, the

_______________ the volume of gas that can be dissolved in it.

Part B

MATERIALS

test tubes, large, 2	drinking straw
bromthymol blue solution	test tube rack

PROCEDURE

1. Pour water into two test tubes until each is two-thirds full. Add to each tube enough bromthymol blue to produce a distinct blue color. Be sure the color is the same in both tubes.

2. Using the drinking straw, gently blow your breath into one of the tubes. Continue this for at least one minute. Observe the color changes. Record the colors in the order of their appearance.

3. When finished with Tube 1, observe Tube 2, which you have not disturbed. Compare its color with that of Tube 1.

INTERPRETATION

1. A substance that visibly changes in the presence of another substance is called an indicator of the second substance. Did bromthymol blue indicate the presence of something in your breath or something in the water? What evidence do you have for your answer?

2. Judging from your previous experience, what do you think may be the gas that was indicated by the color change of bromthymol blue?

3. The amount of any substance that is added to some unit amount of another substance is called the concentration.

    a. What color indicates the least concentration of the gas in water?

    b. What color indicates the greatest concentration of the gas in water?

    c. What color indicates a medium concentration of the gas in water?

4. What might you have done to the water to increase the concentration of the gas that dissolved in it? Explain.

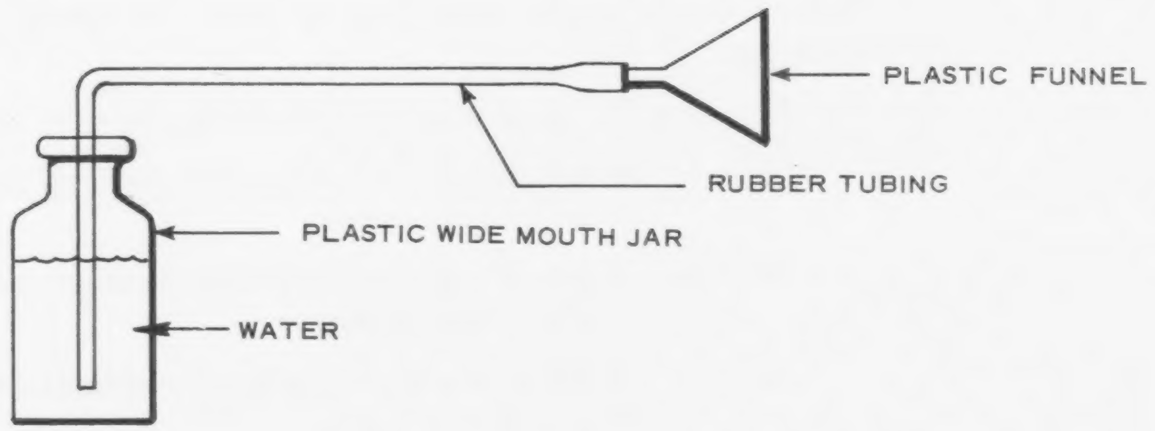
5. Describe a procedure you can use to collect a maximum amount of gas from an automobile exhaust.

ARE YOU SURE?

Part A

MATERIALS

asbestos gloves
gas-collecting apparatus:



PROCEDURE

1. Obtain permission to turn on the ignition key of a car having a single tailpipe.

2. Set up the apparatus as illustrated above. Why should you use water from the refrigerator rather than the tap? (Refer to Investigation E-10.)

3. Start the engine. Using asbestos gloves, hold the funnel over the tailpipe. Be sure the free end of the rubber hose is beneath the surface of the water.

4. Accelerate the engine. Let the gases from the exhaust bubble through the water for at least three minutes.

5. Return the water containing dissolved gases to the classroom for use in the next part of this investigation.

Part B

MATERIALS

beakers, 100 ml, 5
paper towels, 5
water containing exhaust gases
graduate, 25 ml
tap water
bromthymol blue
medicine dropper

PROCEDURE

1. Place 5 empty 100 ml beakers in a line, each on a paper towel. Number the beakers from 1 to 5. Into the beakers place the following:

   No. 1: 40 ml of water containing exhaust gases

   No. 2: 20 ml of water containing exhaust gases
   20 ml of tap water

   No. 3: 13 ml of water containing exhaust gases
   27 ml of tap water

   No. 4: 10 ml of water containing exhaust gases
   30 ml of tap water

   No. 5: 40 ml of tap water

2. Add 8 drops of bromthymol blue to each beaker. Carefully swirl the liquid in the beakers to be sure the bromthymol blue is thoroughly mixed.

3. Examine the liquid in each beaker. Using the terms: royal blue, light green, blue-green, yellow-green, and dark green, identify the color that is present in each beaker. Place your answer in the appropriate column in the following table:

Container	Color
Beaker No. 1	
Beaker No. 2	
Beaker No. 3	
Beaker No. 4	
Beaker No. 5	

INTERPRETATION

1. Why did you use tap water only in Beaker No. 5?

2. What evidence do you have that exhaust gas dissolved in water?

3. From your results, would you say that you had a little or a lot of dissolved gas in water?

4. Using the information from this and the previous investigation, what gas would you suppose is in the exhaust from a car?

Part C

PROCEDURE

1. As you observe the demonstration fill in the following chart:

Chemical Compound	Color
HCl	
HNO_3	
H_2SO_4	
$HC_2H_3O_2$	

2. Look at the formulas. What element is present in each of the compounds?

INTERPRETATION

1. How did the color changes in the demonstration compare with the color changes you observed when you added bromthymol blue to car exhaust and to water that you had breathed through?

2. HCl is the formula for hydrochloric acid. What general name can you give to all of the substances used in the demonstration?

3. For what is bromthymol blue an indicator?

4. What must carbon dioxide in water produce? Give a reason for your answer.

5. Now that you have completed this investigation, what are you sure of?

MEASURING ACID CONCENTRATION

Part A

PROCEDURE

Observe the demonstrations performed by your teacher. When answering the questions, use the following color words: yellow, red, orange-red, yellow-green, orange.

1. What color do you observe in the beaker containing distilled water and the indicator?

2. What color do you observe in the beaker containing the acid and the indicator?

3. Describe any color changes you observe as distilled water is added to the beaker containing tap water and indicator.

4. Describe any color changes you observe as distilled water is added to the beaker containing acid and indicator.

INTERPRETATION

1. Do you think that other acids would have shown the same color changes with this indicator? What evidence do you have to support your answer?

2. Examine the list of formulas of acids in the chart of Investigation E-11. What element is written first in each formula?

3. The hydrogen atom in an acid has a positive electrical charge. The remainder of the acid molecule has a negative charge. For example, HCl is charged thus: H^+Cl^-; $HC_2H_3O_2$ is charged thus: $H^+(C_2H_3O_2)^-$. The charged atoms (or groups of atoms) are called ions. Using a "+" to represent the positive charge and a "-" to represent the negative charge, show how the ions of the following acids look:

HCl

$H(COOH)$

$H(NO_3)$

HBr

HI

$H(HCO_3)$

4. When an acid is in water, the ions separate so that the H^+ ion is not bound to the negative ion of the acid. What do you think produces color changes when an indicator is added to the acid?

5. What evidence from the demonstration shows that the hydrogen ions have not been increased by adding water?

6. Water has the formula H_2O; this can also be written $H(OH)$. However, the ions of water do not separate easily. The negative ion $(OH)^-$ holds the positive ion H^+ so tightly that there are few free hydrogen ions. Why did the indicator show no acid in distilled water?

7. The number scale for measuring acids is called the pH scale. In distilled water the pH is 7, which means no acid. A pH of 6 indicates a slightly acid solution. The stronger the acid the lower the pH.

   a. If table salt, formula NaCl, is added to distilled water, what would the pH be? Give a reason for your answer.

   b. If HCl is added to distilled water how will the pH change?

8. On the arrow below, place the pH numbers from 1 through 7 to indicate the concentration of an acid. Notice the direction of the head of the arrow!

distilled water ⟶ most concentrated acid

9. The acid used at the beginning of the demonstration had a pH of 4.0. The other named colors showed pH's of 5.0, 6.0, 6.5, and 7.0. List the colors with their pH's from the most concentrated acid to distilled water.

10. When water was added to the acid during the demonstration, the acid was diluted. What effect does dilution have on pH?

Part B

Indicator dyes in liquid form are not always convenient. Often the dyes are placed in strips of paper. In this part of the investigation you will use such indicator paper.

MATERIALS

- forceps
- pH paper
- lemon juice
- pH scale
- paper towels
- orange juice
- vinegar
- pineapple juice
- cola drink
- tap water

PROCEDURE

1. Using forceps, pick up a strip of pH paper about 2 cm long. (DO NOT TOUCH THE pH PAPER WITH YOUR FINGERS.) Dip one end of the paper in the lemon juice. Wait one minute, then compare the color of the pH paper to the colors on the pH scale. Place the used piece of pH paper on a towel. Record your results in the following table:

Materials	pH
lemon juice	
orange juice	
vinegar	
pineapple juice	
cola drink	
tap water	

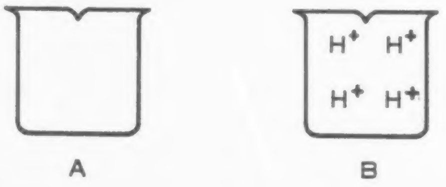
2. Repeat Procedure Step 1 for each of the materials to be tested. Record each result.

INTERPRETATION

1. Considering the entire pH scale, are the concentrations of acid in substances you eat strong or weak? Give a reason for your answer.

2. Which one of the materials that you tested for pH has the greatest concentration of hydrogen ions? Explain your answer.

3. In the diagram below, the symbol "H^+" represents a hydrogen ion. In Container A place symbols to show an acid that is more dilute than that in Container B.



4. Using the terms "pH" and "volume," explain how a diluted acid differs from a concentrated acid.

E-13

ACID ACTION

Part A

MATERIALS

beakers, 50 ml, 2	marble chips, 2
HCl, concentrated	metric rule
HCl, dilute	pH paper
grease pencil	

PROCEDURE

1. Observe the preparation of dilute hydrochloric acid, HCl, from concentrated acid.

   a. Why is the concentration of the dilute acid one-tenth that of the concentrated acid?

   b. If 10 ml of the concentrated acid has 100 H^+ ions, how many hydrogen ions would there be in 10 ml of the dilute acid?

2. Put 20 ml of concentrated HCl into one beaker and 20 ml of dilute HCl into another beaker. So that you may later distinguish the two beakers, use a grease pencil to mark the one containing concentrated acid "conc." and the one containing dilute acid "dil."

3. Measure (to the nearest mm) the length and width of one marble chip. Drop the chip into the concentrated acid. Record the measurements in the appropriate block of the chart below.

Beaker	Size of Chip at Start	Action of Acid on Chip	pH at Start	pH Day 2	pH Day 7	Size of Chip at End
Concentrated acid						
Dilute acid						

4. Measure (to the nearest mm) the length and width of another marble chip. Drop this chip into the beaker of dilute acid. Record the measurements in the appropriate block of the chart.

5. Observe the action of acid on the chip in each beaker. Record your observations in the appropriate blocks of the chart.

6. On the second day after setting up the experiment use pH paper to determine the pH of the acids in the two beakers. Record the pH in the appropriate block of the chart.

7. At the end of a week again determine the pH of the acids in the two beakers and record them in the chart.

8. After recording the pH on the seventh day, use forceps to remove the marble chip from the beaker that originally contained the concentrated acid. Wash the chip and measure its length and width. Record the measurements in the appropriate block of the chart.

9. Repeat Procedure Step 8 for the chip in the beaker containing dilute acid.

INTERPRETATION

1. Compare the three pH measurements of the concentrated acid. What happened to the hydrogen ion concentration? Give a reason for your answer.

2. Compare the three pH measurements of the dilute acid. What happened to the hydrogen ion concentration? Give a reason for your answer.

3. What evidence do you have that the acid acted on the marble?

4. What determines how fast an acid will act on marble?

5. Volume for volume, which of the two beakers had the greater number of hydrogen ions at the start of the experiment?

6. What determines how long an acid will act on marble?

7. Why did you not see, on the first day, that the acid was acting on the marble?

8. "Automobile exhaust gases damage the stone of statues and buildings." Summarize all your evidence that supports this statement.

Part B

MATERIALS

graduate and cylinder, 25 ml
HCl, concentrated
beaker, 50 ml

pH paper
strips of magnesium ribbon, 3 cm long, 5

PROCEDURE

1. Pour 10 ml concentrated hydrochloric acid into a 50 ml beaker. Using pH paper, measure the pH of the acid. Record the measurement.

2. Put one strip of magnesium ribbon in the beaker of the concentrated acid. Record any observations.

3. Continue putting strips of magnesium ribbon into the beaker until there is no further reaction.

4. Using pH paper, measure the pH of the liquid in the beaker when all action has ceased. Record the measurement.

INTERPRETATION

1. Compare your two pH measurements. From this evidence, what element do you think must have been removed from the liquid during the experiment?

2. What additional evidence supports your conclusion?

3. What substance must have become a part of the liquid during the experiment? Give a reason for your answer.

4. If one substance leaves a liquid and at the same time another substance becomes a part of the liquid, the second substance is said to replace the first. Complete the following sentence:

   Magnesium replaced the ____________ in hydrochloric acid.

5. What number on the pH scale indicates the liquid is no longer an acid? (At this point the liquid is said to be neutral.)

6. How do automobile exhaust gases harm metal objects?

E-14

COMBATING ACID DAMAGE

Must the people of all the Newburgs in our country continue to suffer damage to buildings and metals inflicted by acids from automobile exhausts? Clearly this is a technological problem and--as in all such problems--the first step is additional scientific knowledge. What do scientists know about combating acid damage?

MATERIALS

- hydrochloric acid
- graduated cylinder, 25 ml
- beaker, 50 ml
- sodium hydroxide
- pH paper
- pH scale
- medicine dropper
- watch glass

PROCEDURE

1. Pour 5 ml of hydrochloric acid into a 50 ml beaker.

2. Pour 4 ml of sodium hydroxide solution into the beaker containing the hydrochloric acid. Swirl the contents of the beaker to mix the two liquids. Measure the pH of the liquid with pH paper and record the measurement in the appropriate space in the chart.

3. Using a medicine dropper, add ____________ drops of sodium hydroxide solution to the beaker and swirl. (Your teacher will tell you how many drops to add in this and the two following procedure steps.) Measure the pH with pH paper. Record the pH measurement in the appropriate box of the chart.

   Put the medicine dropper on a watch glass when you are not using it.

4. Add ____________ drops of sodium hydroxide solution to the beaker and swirl. Measure pH with pH paper. Record the pH measurement in the chart.

5. Add ____________ drops of sodium hydroxide to the solution and swirl. Measure the pH with pH paper. Record the pH measurement in the chart on Page 57.

6.

Step	pH
Procedure Step 2	
Procedure Step 3	
Procedure Step 4	
Procedure Step 5	

INTERPRETATION

1. From your experience with Investigation E-13, recall the interpretation of pH measurements. Did the solution become more or less acidic as sodium hydroxide was added? Give a reason for your answer.

2. Which ions in the solution decreased in number? What did you observe that supports your answer?

3. Recall that the formula for water may be written $H^+ (OH)^-$. What ion in the formula prevents distilled water from showing an acid pH?

4. The formula for sodium hydroxide is $Na^+ (OH)^-$. Which ion of sodium hydroxide is the one that reduces the acid reaction of hydrochloric acid?

5. What chemical reaction might cause the OH^- ions of the sodium hydroxide to neutralize the H^+ ions of the hydrochloric acid?

6. Complete the formula describing the reaction that took place in the beaker:

H^+Cl^- plus $Na^+(OH)^-$ produced ______________ plus ____________.

7. NaCl is a salt. It is the kind of salt you use in your food. Salts are always produced when acids combine with hydroxides. Complete the following equation:

Any __________________ plus sodium hydroxide produces

__________________ plus a __________________.

8. Compounds written with the (OH) at the right end of the formula are called bases. In the following list of compounds place one line under every base.

NaOH

HCl

KNO_3

KOH

H_2SO_4

HNO_3

HBr

LiOH

NH_4OH

9. Go back to the list above and underline all acids TWICE.

10. If 100 molecules of hydrochloric acid were added to a solution of sodium hydroxide, how many molecules of the base would have to react to neutralize the acid exactly? Explain.

11. What pH would result from the above reaction?

12. Why is water said to be neutral?

13. In Investigation E-13 you put a metal in an acid.

    a. What element bubbled from the solution?

    b. During the reaction, did the solution become more or less acidic? Explain.

14. In what two ways can the acidity of a solution be reduced?

15. Suggest two ways in which you might reduce damage to a marble statue, if the damage results from acids that come from automobile exhaust gases.

Part B

PROCEDURE

Observe the demonstration. List the colors that you observe in the order of their appearance.

INTERPRETATION

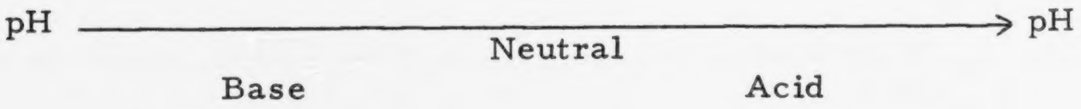
1. Dilution of which ions in the solution produces the color changes? Explain.

2. Recall what the pH of a neutral (neither acid nor base) solution is. The pH number of the strongest base is 14.

   a. As a base becomes weaker, the pH number becomes ______________.

   b. As an acid becomes weaker, the pH number becomes ______________.

3. Place the pH numbers 1, 7, and 14 at their proper places on the following arrow:



Part C

MATERIALS

pH scale	drain cleaner
pH paper	milk of magnesia
borax	ammonia solution
soap	

PROCEDURE

Use pH paper to test the solutions listed in the chart on the following page. Fill in the information requested for each.

Solution	pH	Acid or Base
Borax		
Household ammonia		
Soap		
Drain cleaner		
Milk of magnesia		

INTERPRETATION

1. Recall the pH of vinegar. If vinegar were spilled on the floor, which of the solutions that you tested could be used to neutralize it? Explain.

2. What kind of solution, an acid or a base, could be neutralized by soap?

3. How could you determine whether any additional household substances were acids or bases?

4. Milk of magnesia is used for an upset stomach. Which pH, 4 or 9, is the probable pH of the stomach contents? Explain your choice.

E-15

A GRAY DAY

As Newburg grew, a coal-fired electrical generating plant was a necessary addition to the town. Then a few factories were established. The clear blue that once capped Newburg seldom appeared. Black plumes of smoke blended with yellowish-white automobile exhaust to make a uniform gray dome. Laundry hanging in the back lawns of Newburg became dingy despite the detergents. Cars in the driveways bore finger writing in the dust that cloaked them.

MATERIALS

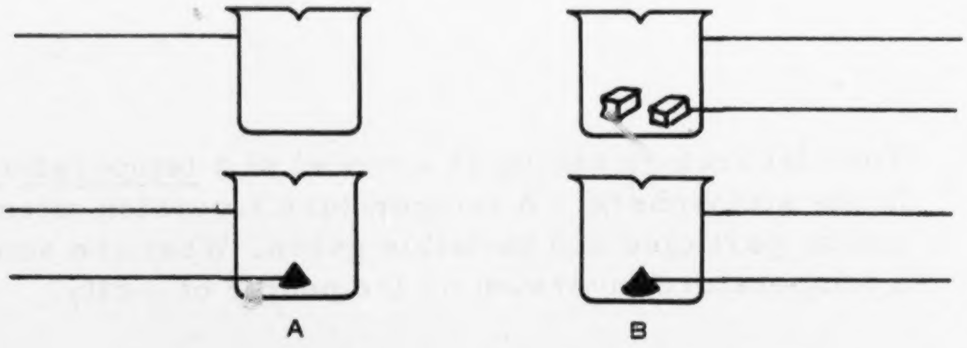
beakers, 1000 ml, 3	ice cubes, 4
incense cones	matches

PROCEDURE

1. Put three or four ice cubes into a 1000 ml beaker. Put an incense cone on the center of the bottom of another 1000 ml beaker. Thoroughly rinse a third 1000 ml beaker with very warm water.

2. Light the incense cone and let it burn until a thick stream of smoke trails from it.

3. Hold the warmed beaker bottom-side down, about 5 cm over the top of the beaker from which the smoke is emerging. Observe the path of the smoke. In Diagram A below show, by means of pencil lines, the direction of smoke movement.



4. Remove the warmed beaker. Now hold the beaker containing the ice cubes about 5 cm above the same smoking beaker used in Step 3. Observe the path of the smoke. In Diagram B show, by means of pencil lines, the direction of smoke movement.

5. Label both diagrams to indicate what each part of the experimental set-up represents. Consider the following: the city, a factory, a warm air mass, a cold air mass.

INTERPRETATION

1. Summarize the effects of an alternation of warm and cold air over a smoke source.

2. Factories are not the only source of smoke pollution in the atmosphere. List as many other sources as you can.

3. Smoke pollution, in a narrow sense, means pollution by particles that float in the air and are visible when numerous. Suggest some ways that smoke pollution, in this narrow sense, might be controlled.

4. Your laboratory set-up is a model of a temperature inversion in the atmosphere. A temperature inversion affects both visible smoke particles and invisible gases. What are some effects of a temperature inversion on the people of a city?

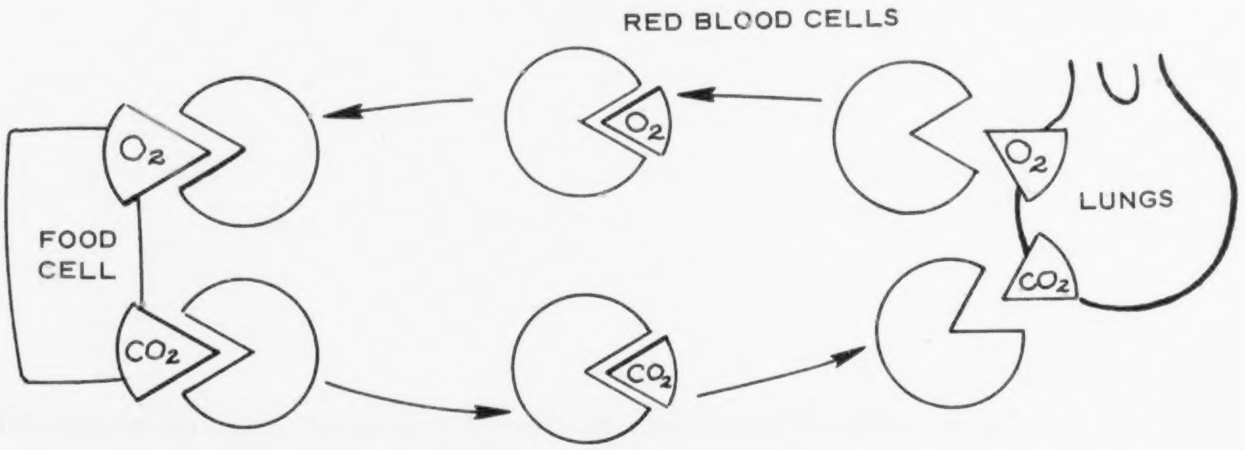
THE GAS CHAMBER

In addition to carbon dioxide many other gases are found in automobile exhaust and in factory smoke. Some of these gases, such as carbon monoxide, you have probably heard about. Others, such as sulfur dioxide and nitrous oxide, may be unfamiliar to you. But, known or unknown, they are daily a part of the air you breathe.

Part A

PROCEDURE

Read the paragraphs and study the diagram below:



Carbon monoxide is a gas that keeps your red blood cells from doing their job. Therefore it has a serious effect upon your health. To understand this effect you should recall some facts about your blood and circulation.

Hemoglobin is a substance in red blood cells. Hemoglobin acts something like a cargo ship. It picks up oxygen from your lungs and carries it to the cells of your body. Here, the oxygen combines with substances derived from food molecules. In doing this job, it releases the energy that you use in all your activities.

In releasing energy to your cells oxygen combines with carbon. The gas that results is carbon dioxide. The hemoglobin that carried oxygen to your cells lost its cargo. Now it takes on the carbon dioxide. It carries this gas to your lungs, where it is released.

Once again hemoglobin has no cargo; it can pick up oxygen to take back to your cells. And so this exchange of oxygen and carbon dioxide goes on continuously as long as you live. Chemically, carbon monoxide is much like carbon dioxide. Unfortunately, it is even more attractive to hemoglobin. When a hemoglobin molecule picks up a carbon dioxide molecule, it holds on to it tightly and does not let it go. And worse,having a cargo of carbon monoxide, that hemoglobin molecule cannot pick up a cargo of oxygen. If carbon monoxide is present in air, you inhale it. Every molecule of carbon monoxide you breathe destroys the oxygen-carrying ability of one of your hemoglobin molecules. As you breathe in more and more carbon dioxide you can neither get oxygen nor get rid of carbon monoxide.

INTERPRETATION

1. In your own words explain why you would die if you breathed in much carbon monoxide.

2. Even under conditions of heavy pollution carbon monoxide molecules are not abundant enough to cause quick death. However, under such conditions you may get a little carbon monoxide in your lungs hour after hour and day after day. What do you think would be the effects of such conditions on you? Explain your answer.

Part B

PROCEDURE

1. Your teacher will demonstrate the laboratory production of sulfur dioxide. Describe the color and the odor of the gas.

2. Observe the bubbling of sulfur dioxide through water. Carefully smell the liquid. Compare the odor of the liquid with the odor of the gas.

3. Observe the effects on pH paper of water through which sulfur dioxide has been bubbled. Record the pH obtained from:

   a. tap water ______________________________

   b. sulfur dioxide water ____________________

4. Observe the effect of sulfur dioxide on a wet piece of colored cloth and on a wet piece of nylon.

   a. Describe any change that occurred in the colored cloth.

   b. Describe any change that occurred in the nylon.

5. Observe the effects of sulfur dioxide on a silver teaspoon.

   a. Describe the spoon before exposure to the gas.

b. Describe the spoon after the exposure to the gas.

6. After one week observe the two plants that were set up on the day of the demonstration.

   a. Describe the plant that was not exposed to the sulfur dioxide.

   b. Using your description in 6a as a basis, list any differences that you observe in the plant that was exposed to sulfur dioxide.

INTERPRETATION

1. Judging from the way the apparatus is set up, do you think sulfur dioxide is a gas that is heavier or lighter than air? Explain.

2. Why is the weight of a gas, as compared to air, something to consider when determining the effect of a gas on living things?

3. Re-examine the data you collected in Procedure Steps 2 and 3.

   a. How would sulfur dioxide from automobile exhaust or from factory smoke get into the water?

   b. Why would you have difficulty knowing that sulfur dioxide is in water if you had to rely on your sense organs?

   c. What is produced when sulfur dioxide dissolves in water? Give evidence for your answer.

4. Explain the effects of sulfur dioxide on wet colored cloth and wet nylon. Hint: Re-examine Procedure Step 4.

5. You have probably observed silver objects that appeared much like the spoon you exposed to sulfur dioxide in the laboratory. Name some ways in which silver objects outside the laboratory might be exposed to conditions that might affect them in this way.

6. Why did you use two plants in the experiment?

7. Give at least two reasons why gas damage to plants is indirectly damaging to man.

ONE BIG NEWBURG

As long ago as Investigation E-6, you learned that Newburgs are everywhere. Newburg is a convenient symbol for the whole problem of pollution. Understanding of the problem must begin with something simple and easily visualized -- with Newburg.

But, of course, the pollution problem is not just a problem facing the Newburgs of the United States. It is a problem facing the whole of Earth. Therefore, a world view now becomes important.

PROCEDURE

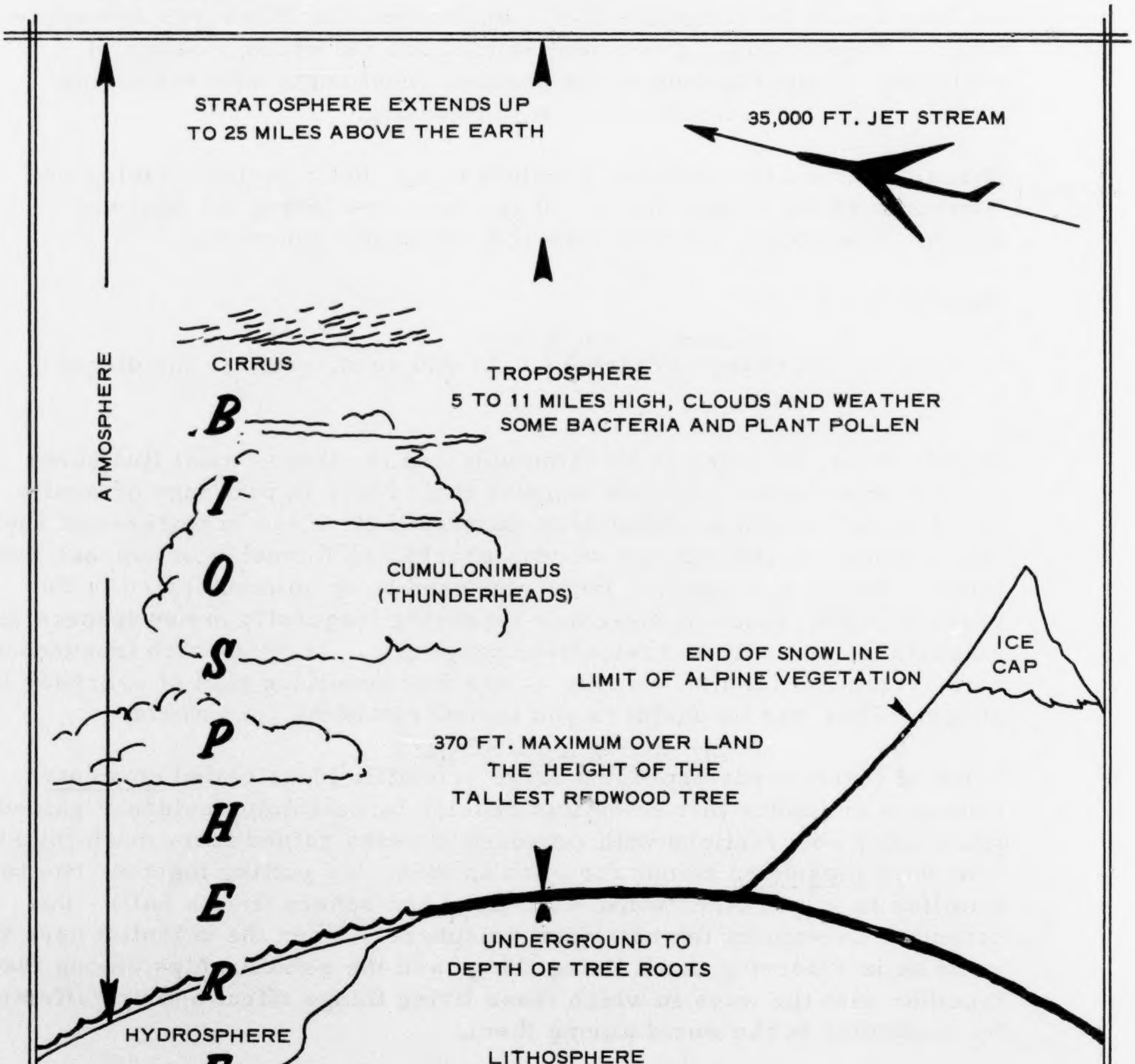
Read the following paragraphs. As you read, refer to the diagram on the next page.

Human ideas, in order to be communicated to others, must find some form of expression. Artists express their ideas in paintings or sculptured pieces of stone. Musicians express their ideas in patterns of rhythmical tones. Scientists use words, graphs, and formulas to express their ideas. Because scientific ideas now need to be communicated to the general public, many of these are appearing frequently in newspapers and magazines, on radio and television programs. Through such frequent usage many scientific terms -- words -- are fast becoming part of everyday language. They can be useful to you in understanding your world.

Some of these words represent large scientific ideas called concepts. Concepts are ideas that scientists develop by combining evidence gained from many observations with reasoned guesses gained from much thinking. The word biosphere stands for such an idea. By putting together two terms familiar to you in other ways - bio (life) and sphere (like a ball) - the scientist constructs the new word biosphere. When the scientist uses this word he is referring to all living things and the relationships among them, together with the ways in which these living things affect and are affected by conditions in the world among them.

Life occurs under many different conditions. In general, living things inhabit water, air, and the solid earth. When scientists think of the water on the earth they use the word hydrosphere. All the air, including that which penetrates the soil and mixes with the water, they call the atmosphere. All the solid crust, including the dry land areas of the earth, they call the lithosphere. Water, air, and earth all affect living things in many ways. And, in turn, living things affect the hydrosphere, atmosphere, and lithosphere.

As you use these words over and over, they will become familiar to you. Familiarity with the words allows you to use the ideas that they represent. These ideas are necessary when you think about Planet Earth as a whole. And because pollution is a world-wide problem, you must think of Earth as a whole.


STRATOSPHERE EXTENDS UP TO 25 MILES ABOVE THE EARTH
35,000 FT. JET STREAM
ATMOSPHERE
CIRRUS
TROPOSPHERE 5 TO 11 MILES HIGH, CLOUDS AND WEATHER SOME BACTERIA AND PLANT POLLEN
BIOSPHERE
CUMULONIMBUS (THUNDERHEADS)
END OF SNOWLINE LIMIT OF ALPINE VEGETATION
ICE CAP
370 FT. MAXIMUM OVER LAND THE HEIGHT OF THE TALLEST REDWOOD TREE
UNDERGROUND TO DEPTH OF TREE ROOTS
HYDROSPHERE
LITHOSPHERE EARTH'S CRUST
SOME LIFE EXISTS DOWN TO OCEAN FLOOR
EARTH'S CENTER 3,959 MILES

INTERPRETATION

1. **List some ways in which you think the hydrosphere, atmosphere, and lithosphere affect the biosphere.**

Hydrosphere	Atmosphere	Lithosphere

2. Is it possible to separate sharply the areas named by the terms lithopshere, hydrosphere, and atmosphere? Explain.

3. Describe a change in any one of these "spheres" that might produce effects in one or more of the others.

4. Study the diagram again. Think about the entire Planet Earth as it is represented by a model -- a globe. In your own words, write definitions for the terms lithosphere, hydrosphere, atmosphere, and biosphere.

EARTH: A FINITE SYSTEM

Back of the big pollution problem that faces us today is the delusion that the biosphere is infinite. You may recall the word "infinity" from your experience in mathematics. The concept for which the word stands includes such ideas as: beyond calculation, unthinkably large, limitless, without boundary. If the atmosphere is infinite, no harm can come from pouring into it smoke and gases. If the hydrosphere is infinite, no harm can come from pouring into it fertilizers, sewage, poisons. If the lithosphere is infinite, no harm can come from littering it with garbage.

In fact, however, Earth is a finite planet. The lithosphere has dimension. The hydrosphere has boundaries. Even the atmosphere has a limited capacity to hold substances now being dumped into it. Hydrosphere, lithosphere, and atmosphere are all exhaustible. And the continued existence of the biosphere depends upon man's recognition of this fact.

Facts concerning the finite dimensions of the earth are known. Facts are to an imaginative scientist as objects are to an artist; they can be joined together to make new designs.

PROCEDURE

1. Read these facts about the earth:

    a. The total land area of the earth is 57,280,000 square miles.

    b. The total water area of the earth is 139,660,400 square miles.

    c. The total area of arable land (land that can be cultivated) is 12,500,000 square miles.

    d. There are 640 acres in a square mile.

    e. The part of the atmosphere that circulates extends for an average distance of 6 miles above sea level.

    f. The present estimated world population increase is 2% per year.

    g. In 1970 the estimated world population was 3,500,000,000.

2. Now try putting some of these facts together to make meaningful statements. Start by using the facts to answer these questions:

a. What percentage of the land area of the earth is considered arable?

b. How many acres of arable land per person existed in 1970?

c. About how many cubic miles of circulating air per person existed in 1970 for each person?

d. What is your estimate of world population for 1980?

e. On the basis of this estimate, how many acres of arable land per person will exist in 1980?

3. Using these same facts, devise two questions of your own and work out answers:

a.

b.

4. Facts concerning the dimensions of world-wide pollution are difficult to obtain. However, facts on pollution in the United States are becoming available. Using sources suggested by your teacher, gather facts concerning pollution in the United States and list them below.

INTERPRETATION

Using the facts you have gathered, write a description of pollution in the United States. Then, in a concluding paragraph, relate the dimensions of pollution in the United States to the resources of water, air, land, and people.

E-19

WHO IS GUILTY?

Newburg is not a nice place to live anymore. There are no woods or open spaces left. In their places are high-rise apartment buildings, highways, parking lots, gas stations, and drive-in restaurants. The open spaces are missed by the older residents who remember childhood times not so long ago when they had secret places. The youngsters of today are part of the mob that moves routinely through the maze of man-made sights, sounds, and smells of Newburg. There are just too many faces in Newburg for anyone to care much about individual ones. So the residents of Newburg pass each other—unknowing, uncaring. There are just too many. And more people are arriving -- faster and faster!

The real estate business in Newburg is booming to keep pace with the growing numbers of people. Thousands of look-alike houses look out upon each other over treeless lawns.

There is a large red sign down by the lake now. "Danger. No swimming, boating, or fishing. Polluted." The lake is dead. Who killed it? Who killed the fish and birds? Who poisoned the water? Some say it was the factories which used the lake for quick, cheap disposal. Some say it was the home owners, who dumped countless tons of growth chemicals on their yards. Some blame others, but most just don't care.

Down by the river is a large power plant. From its stack come tons of dust and stinking gases. They rain down over Newburg slowly. The songbirds have disappeared, statues of the founding fathers have been eaten away, and everything gets dirty more quickly. The sun doesn't shine as brightly now, and there are many more respiratory diseases. "But we've got to have increased electric power," is the cry. Television sets, air conditioners, electric toothbrushes, and a host of other life necessities are gobbling up electric current at a rate unequaled by any other time or place.

The river water is warmer than before. The fishing isn't good anymore; some say it's not the temperature but rather the raw sewage. Others claim that it's really the 20-year build-up of detergents. Still others protest loudly that the real culprit is the same floating oil that closed down the local beach. But, after all, everyone needs oil. So maybe it's a price we have to pay.

There's been quite a big stir lately in Newburg. The newspapers and magazines warn expertly of the dangers of the exhaust of automobiles. Monoxides, dioxides, hydrocarbons, and other long-named chemicals are producing harmful and lasting effects on the environment and even on human bodies. The car manufacturers plead innocence. "We are only producing what the public wants and is willing to pay for," they claim. "Well, how can you get along without a car?" comes the response from the residents of Newburg. In fact, many residents have two, even three cars.

So, who is to blame? Who wanted the fine lawns and the crops supported by chemical fertilizers? Whose sewage was dumped into the river? For whose benefit was the electric power plant operated? Who needs the oil carried on the river? Who uses the products produced by the factories? Who burns the gasoline? Whose trash is being burned in incinerators? Whose bottles and cans occupy increasing volumes of precious space? Whose little bits and scraps of rubble litter the highways.

IF YOU'RE NOT PART OF THE SOLUTION,

YOU'RE PART OF THE PROBLEM.

WHAT PROBLEM?

WHOSE PROBLEM?

MATERIALS

beaker, 600 ml
pH paper
pH scale
microscope
slide
cover slip
medicine dropper

PROCEDURE

1. Examine the contents of the beaker carefully. It is a model of Lake Newburg. Identify all the different pollutants that you see. Use the microscope to check for pollution by microorganisms and pH paper to check for acid pollution.

2. In the chart on the next page list each pollutant separately in the boxes at the top.

3. For each pollutant use checks opposite the items of Sections A and B to show what you know (or think) about the kinds of pollution. In the spaces opposite Sections C and D write either "Yes" or "No."

	Name of Pollutant				
A. Where pollution comes from					
1. Nature					
2. Homes					
3. Farmland					
4. Business					
5. Industry					
6. Ships					
B. Reasons for pollution					
1. Helps make money					
2. Saves time					
3. Carelessness					
4. Indifference					
5. Accidents					
6. Unavoidable					
C. Am I harmed in any way by this pollutant?					
D. Am I helped in any way by this pollutant?					

INTERPRETATION

1. What are the principal sources of the pollutants that you found in your water?

2. What were the principal reasons for the pollution you found?

3. Which of the kinds of pollution you found could be harmful to you?

4. Which of the kinds of pollution you found are helpful to you?

5. In what ways has the growth of Newburg caused the pollution we have studied?

OBJECTIVES

1. Identify changes that occurred from the time Newburg was a farm until it became a housing development.
2. Construct a model that shows the leaching of soil.
3. Demonstrate the need for a control.
4. Distinguish between facts and assumptions.
5. Demonstrate the skills necessary for use of a balance.
6. Construct a model showing how materials dissolved in water can become concentrated through distillation.
7. State a rule that relates the concentration of soluble substances to evaporation.
8. Order the events responsible for a lake changing color.
9. Demonstrate by use of a controlled experiment, the differences between a polluted and an unpolluted environment.
10. Identify the agent that causes the death of the goldfish.
11. Describe the effects of the above-named agent on goldfish.
12. State a rule that relates the quantity of pollutant to its effect on a goldfish.
13. Construct a statement that tells the effect of a very small amount of pollutant.
14. Construct a statement that relates the problem of pollution of water by detergents to pollution of water by algae and bacteria.
15. Identify on a map the location of home.
16. Name the bodies of water into which drainage from the home area occurs.
17. Describe the paths of drainage from selected areas of Baltimore County into the Chesapeake Bay.
18. Construct a statement that relates the pollution of one body of water to the pollution of other bodies of water.

19. Describe the causes and effects of the pollution of water by sewage.

20. Name a principal pollutant in water.

21. Distinguish between polluted and unpolluted water.

22. Demonstrate the method by which the amount of dissolved oxygen is determined.

23. Describe the effects of raw sewage on the dissolved oxygen content of water.

24. Demonstrate the release of gases from water as temperature increases.

25. State a rule relating the temperature of water to the amount of dissolved gases it can hold.

26. Demonstrate the procedure for determining the relative amount of oxygen in water.

27. Construct a statement relating the number of power plants in an area to the amount of dissolved oxygen in the water.

28. Identify the location of existing and proposed power plants in the Chesapeake Bay region.

29. State the rule that explains the behavior of oil on water.

30. Construct methods for removing oil from the surface of water.

31. Demonstrate methods for removing oil from the surface of water.

32. Describe the effect of various materials on oil.

33. Distinguish between effective and ineffective or practical and impractical methods of removing oil from the surface of water.

34. State the rule that relates the temperature of a liquid to the amount of gas that can dissolve in it.

35. Order the color changes in bromthymol blue as the dissolved carbon dioxide in the liquid containing it either increases or decreases in concentration.

36. Name the element that must be present in all acids.

37. Demonstrate a technique used to identify an acid.

38. Identify the ion that is written first in the formulas of acids.

39. Order the pH numbers of acids from pH 1 to pH 7.

40. Using pH paper, identify familiar household substances as acids.

41. Describe the process of neutralizing an acid by adding a metal to it.

42. State a rule that relates the rate that hydrogen ions are replaced by metals to acid concentration.

43. Distinguish between the formulas for acids and bases.

44. Demonstrate the production of a salt and water from the reaction of an acid and a base.

45. Identify some common household products as being either acidic or basic.

46. State a rule describing the effect of temperature on the direction of the flow of gas.

47. State the rule that carbon monoxide reduces the oxygen-carrying function of blood.

48. Demonstrate that sulfur dioxide is injurious to plants and to some non-living things.

49. Construct statements that define the words biosphere, hydrosphere, atmosphere, and lithosphere.

50. Identify some of the finite features of Planet Earth.

51. Construct inferences concerning pollution based on facts gathered from current literature.

52. State a rule that fixes responsibility for pollution.

53. State a rule that relates pollution to technological development and human population.

BOARD OF EDUCATION OF BALTIMORE COUNTY

TEACHERS' MANUAL

SENIOR HIGH SCHOOL SCIENCE

EVERYMAN'S PROBLEM

A Unit on Pollution and the Environment

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Towson, Maryland
1970

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EVERYMAN'S PROBLEM

A Unit on Pollution and the Environment

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FOREWORD

As a part of a continuing effort to upgrade science teaching in the Baltimore County Schools, a committee was organized in the fall of 1969 to study provisions in science for non-academically oriented students in the senior high schools. This committee, co-chaired by John S. Heck and Audrey J. Cheek, made a thorough-going study, and late in the spring of 1970, submitted a comprehensive report.

Based on the recommendations in this report, the 1970 Senior High School Science Summer Workshop Committee developed a series of units for the non-academic student. This bulletin is a teacher's manual for one of these units.

The Office of Science wishes to express its deep-felt appreciation to the members of the above-mentioned committees:

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John S. Heck, Chairman, Senior High School Science Curriculum Committee

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August, 1970

EVERYMAN'S PROBLEM

A Unit on Pollution and the Environment

Overview

Almost daily the mass media confront us with reports of the earth's pollution and the plight of the environment. People's reactions range from active demonstration, to doomsday predictions, to absolute apathy. Students are exposed to both the reports and the reaction. Some of them may even identify with one or another of the various positions.

Unfortunately, much of what a young person hears and sees suggests that the problems are simple. He is often led to believe that the issues are either right or wrong, good or bad; and that individuals or groups are either heroes or villians. In reality, the causes of environmental pollution are enormously complicated and the issues much more involved than the mass media indicate.

The young person of today needs to be concerned about the air he breathes, the water he drinks, and the food he eats. But he needs to know that problems are rarely solved by emotion alone. To make decisions, he needs facts. He must understand the real nature of pollution: what it is, where it is, and what it denotes. If he is to put pollution problems in perspective, he must realize that the plight of the environment is a direct result of his way of life, i. e., he needs to understand his relationship to the environment. He also needs to be calm but concerned as he evaluates the various points of views about pollution being disseminated by the mass media.

It is the intent of this unit to give the student opportunities to gather the information necessary to make informed decisions about pollution and the environment.

Objectives

The objectives for the unit are listed below. They are also listed in the back of the student manuals, but in a somewhat generalized form so that students cannot "find the answers" without doing the investigations.

1. Identify changes that occurred from the time Newburg was a farm until it became a housing development.
2. Construct a model that shows the leaching of soil.

3. Demonstrate the need for a control.
4. Distinguish between facts and assumptions.
5. Demonstrate the skills necessary for use of a balance.
6. Construct a model showing how materials dissolved in water can become concentrated through distillation.
7. State a rule that shows that in a solution, the concentration of soluble substances increases as the evaporation process proceeds.
8. Order the events responsible for a lake changing color.
9. Demonstrate by use of a controlled experiment, the differences between a polluted and an unpolluted environment.
10. Identify the detergent as the agent which causes the death of the goldfish.
11. Describe the effects of detergent on goldfish.
12. State a rule thet the greater the quantity of pollutant the greater the harm to the goldfish.
13. Construct a statement that tells the effect of a very small amount of pollutant:
14. Construct a statement that relates the problem of pollution of water by detergents to pollution of water by algae and bacteria.
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16. Name the bodies of water into which drainage from the home area occurs.
17. Describe the paths of drainage from selected areas of Baltimore County into the Chesapeake Bay.
18. Construct a statement that the pollution of one body of water leads to the pollution of other bodies of water.
19. Describe the causes and effects of the pollution of water by sewage.

20. Name bacteria as a principal pollutant in water.

21. Distinguish between polluted and unpolluted water.

22. Demonstrate the method by which the amount of dissolved oxygen is determined.

25. State the rule that, as the temperature of water increases, the amount of dissolved gases decreases.

26. Demonstrate a procedure for determining the relative amount of oxygen in water.

27. Construct a statement indicating that, as the number of power plants in an area increases, the amount of dissolved oxygen in the water in the area decreases.

28. Identify the location of existing and proposed power plants in the Chesapeake Bay region.

29. State a rule that oil is less dense than water, and thus floats on the surface of the water.

30. Construct methods of removing oil from the surface of water.

31. Demonstrate absorption, burning, and dispersal methods for removing oil from the surface of water.

32. Describe the effects of various materials on oil.

33. Distinguish between effective and ineffective or practical and impractical methods of removing oil from the surface of water.

34. State the rule that the lower the temperature of a liquid the greater the amount of gas that can dissolve in it.

35. Order the color changes in bromthymol blue as the dissolved carbon dioxide in the liquid containing it either increases or decreases in concentration.

36. Name hydrogen as the element that must be present in all acids.

37. Demonstrate a technique used to identify an acid.

38. Identify the ion that is written first in the formulas of acids.

39. Order the pH numbers of acids from pH 1 to pH 7.

40. Using pH paper, identify familiar household substances as acids.

41. Describe the process of neutralizing an acid by adding a metal to it.

42. State a rule that relates the rate that hydrogen ions are replaced by metals to acid concentration.

43. Distinguish between the formulas for acids and bases.

44. Demonstrate the production of a salt and water from the reaction of an acid and a base.

45. Identify some common household products as being either acidic or basic.

46. State a rule describing the effect of temperature on the direction of the flow of gas.

47. State the rule that carbon monoxide reduces the oxygen-carrying function of blood.

48. Demonstrate that sulfur dioxide is injurious to plants and to some non-living things.

49. Construct statements that define the words biosphere, hydrosphere, atmosphere, and lithosphere.

50. Identify some of the finite features of Planet Earth.

51. Construct inferences concerning pollution based on facts gathered from current literature.

52. State a rule that fixes responsibility for pollution.

53. State a rule that relates pollution to technological development and human population.

THE NEWBURG STORY

OBJECTIVE

Identify the changes that occurred from the time Newburg was a farm until it became a housing development.

TEACHING SUGGESTIONS

Preparation

Assemble a clean, wide-mouthed, one-gallon jug, a clean drinking glass, a can of used crank-case oil, and a can of lye. Paste a large, clearly marked label reading "DIRTY OIL" on the can of crank-case oil, another label reading "LYE" on the can of lye and a third label reading "CLEAN WATER" on the drinking glass.

Procedure

1. **Introduce the unit by performing the following activities silently:**
    - a. **Fill a gallon jug with water from the tap. Pour water from the gallon jug into the drinking glass. Drink the water in the glass and place the glass on the table.**
    - b. **Hold up a jar of lye and dramatically pour about a half a cup into the gallon jug. Add a cup of the crank-case oil to the lye and water. Shake the mixture in the jug gently and pour a glassful into the drinking glass.**

      Place the glassful of the mixture on the table, still holding it with one hand. Pause. Then ask, "Would you drink this?" When the noise evoked by this question subsides, say, "Would you bathe in this?"
2. **Continue the lesson by discussing the analogy of your demonstrations to what has really happened in Baltimore Harbor or some other body of water. Discuss other obvious forms of water pollution, such as sewage wastes from ships. If possible, use current news stories.**
3. **Lead into a first reading of the Newburg Story by stating that pollution is not confined to harbors. The Newburg Story will describe how other kinds of pollution arise. As students read the story, have them pick out phrases that describe the**

original farmland and list them in the first column of the chart in the student manual. Similarly, have them write phrases in the second column that describe Newburg as a polluted residential area.

4. Follow the reading with a discussion of the probable causes of and the problems presented by the changes from a farm to a residential community.

Expected Results

Farm Area	Residential Community
grew wheat, tomatoes, and corn	grew grass
caught sunnies and bass	weren't catching fish
swam in the lake	motors of boats fouled with water weed
shot squirrels and rabbits	lake became murky
	foul odor seeped from lake

BETTER HOMES AND GARDENS

OBJECTIVES

1. **Construct a model that shows the leaching of soil.**
2. **Demonstrate the need for a control.**
3. **Distinguish between facts and assumptions.**

TEACHING SUGGESTIONS

Preparation

1. **Make a transparency of the diagram of Newburg for use on the overhead projector. Save this transparency for future use.**
2. **Crush 20 "plant food" tablets into 250 ml of soil. This is enough soil to be divided among 10 to 15 groups. Exact measure is not important. Use fairly porous, not clay soil.**
3. **Set aside space for each laboratory group to store watch glasses.**

Procedure

1. **Introduce the lesson by showing a transparency of Newburg.**
    a. **Ask students for possible explanations for the pollution of the lake. Use story and diagram only. List responses on board.**
    b. **Use student ideas regarding the relationships of the land to the water as a basis for building the model that is outlined in the procedure in the student manual.**
2. **Ask students how they can be sure that substances in water do indeed come from fertilizer in soil and not from unfertilized soil or water. If necessary, suggest use of controls.**
3. **Using students' suggestions as far as possible, plan the following controls:**
    a. **Filter plain water into watch glass.**

b. Filter into a watch glass a mixture of water and soil with no "plant food" tablets added.

c. Filter into a watch glass a solution of water and "plant food" tablets.

Assign special student groups to carry out the control procedures.

4. Distribute equipment and have students carry out the procedure. Caution students not to pour muddy water over the top of the filter paper and not to boil away all of the clear filtrate. The laboratory procedures will take the remainder of the period.

5. The next day have the students observe the watch glasses, comparing experiments with the controls. Then have students complete the investigation questions.

7. Conduct a brief discussion, checking on the observations and summarizing the interpretation questions.

Expected Results

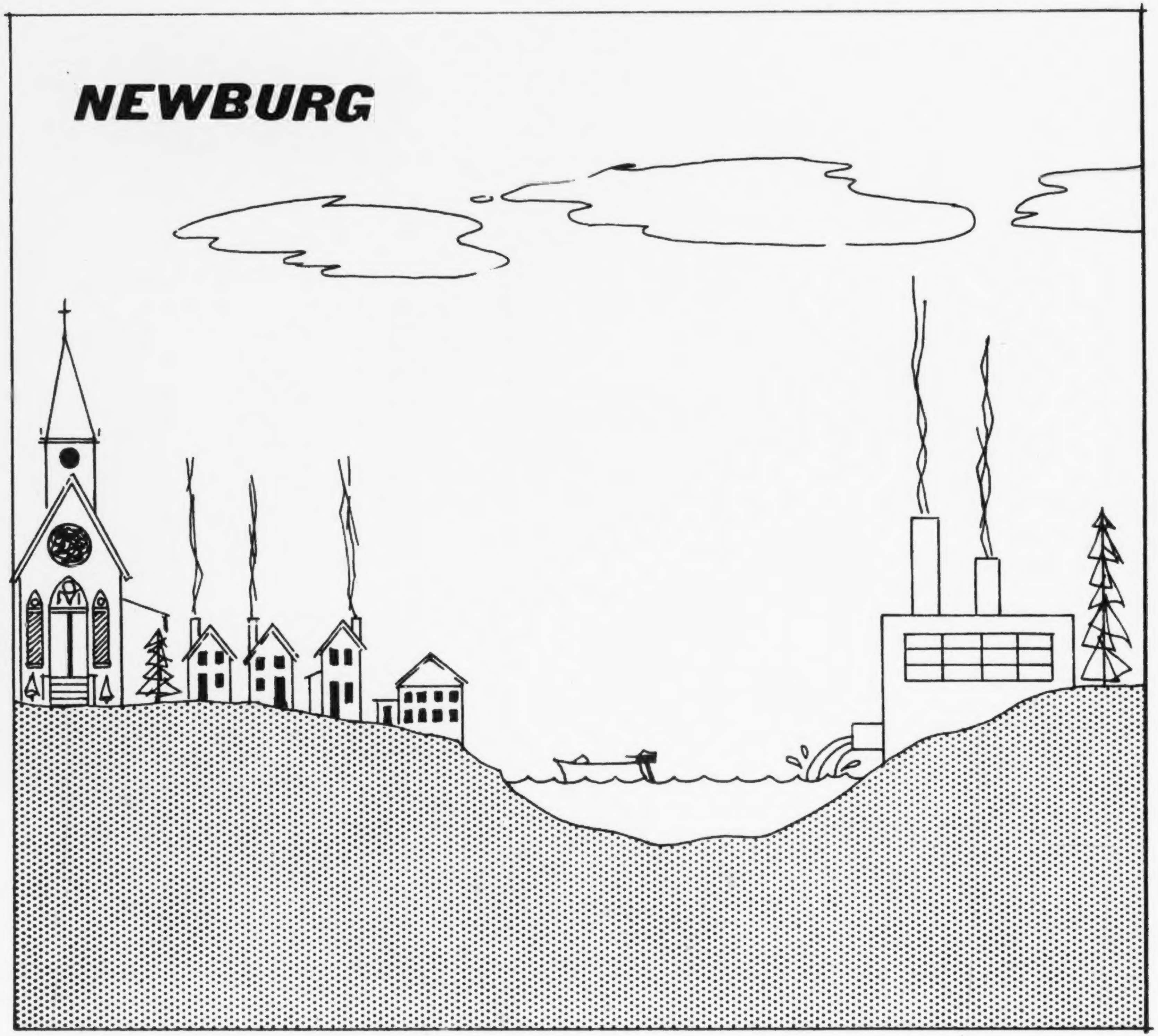
When evaporated, the water used to leach the experimental soil and the control containing "plant food" and water (c) should yield pale yellowish orange crystals in the watch glass. The other two controls may show a faint smudge or a few white crystals.

Responses to Interpretation Questions

1. The substance crystallized in the bottom of the watch glass came from the soil.

2. This substance must be the fertilizer ("plant food" tablets) since neither the filtrate of the water nor that of the soil without fertilizer has this substance. Further proof is that the substance resembles that in the filtrate of the dissolved fertilizer.

3. Yes, the guess is valid because it is supported by evidence from the experiment.


NEWBURG

THICKER THAN WATER

OBJECTIVES

1. Demonstrate the skills necessary for use of the balance.

2. Construct a model showing how materials dissolved in water can become concentrated through distillation.

3. State a rule that shows that in a solution, the concentration of soluble substances increases as the evaporation process proceeds.

TEACHING SUGGESTIONS

Preparation

1. Set up containers holding approximately 15 g of salt for each group. Students need only 10 g. Set up one container holding approximately 25 g of salt.

2. Provide space to set aside beakers for drying until the following day.

Procedure

1. In the investigation "Better Homes and Gardens" the students have seen that soluble substances leach from soil into water. Raise the question, "What happens to the concentration of dissolved substances in water over a period of time?"

2. Review the use of the balance.

3. Distribute all materials. Provide one group with the container holding approximately 25 g of salt. This group will not only follow Procedure Steps 3 through 16, but will also conduct an investigation to support the answer to Interpretation Question 3.

4. Assist students in obtaining accuracy during the weighing.

5. Following Procedure Step 4 have students label beakers with team symbols and set aside until the following day.

6. The following day have students complete the procedure and then write answers to the interpretation questions.

7. Open a discussion of results with a brief review of the leaching of soils. On the chalkboard construct the following chart:

Team	Weight of Salt before Evaporation	Weight of Salt after Evaporation
TOTALS	g	g

8. Compile results from the student teams and complete the chart.

9. Initiate a discussion by referring to the totals on the chart, which support an answer to Interpretation Question 1.

10. Continue the discussion based on the interpretation questions. When Question 3 is reached, have the teams that worked on this question report results to the class.

11. Conclude the discussion with strong emphasis on Questions 6 and 7.

Expected Results

The salt should be totally reclaimed. Only the water evaporates. Soluble materials accumulate through evaporation.

Responses to Interpretation Questions

1. The weights are the same.
2. The salt remained in the beaker.
3. The new weight would be 20 g because the salt does not evaporate.
4. The sun normally supplies the heat energy for evaporation.
5. Applying the results of this experiment, the student would conclude that the concentration of soluble substances should have increased over the years, as more substances are

washed in and water is evaporated.

6. The experimental model makes no allowance for outflow of water. Lakes of the kind represented by Lake Newburg actually have outflow, either by outlet streams or by seepage. Therefore, the concentration of solutes is not as drastic as in the experiment. In fact, the effects tend to be seasonal: in the summer outflow is minimal and evaporation is maximal, so concentration is maximal. By coincidence this concentration occurs in the season most favorable for plant growth.

7. The substances from the lawns and gardens, since they are fertilizers, may cause increased growth of the water plants.

Assessment Task

Scientists have noted that the Great Salt Lake in Utah has become saltier over the years. In the light of your findings in this experiment, explain.

Acceptable Response

The minimal response is in terms of the experiment. Additional points may be added in terms of the discussion of Interpretation Question 6 by students familiar with the geology and climatology of Utah; for example, lack of outlet to the present lake and the high evaporation/precipitation ratio.

A LAKE CHANGES COLOR

OBJECTIVE

Order the events responsible for a lake changing color.

TEACHING SUGGESTIONS

Preparation

1. Collect one unit of the materials listed for each group of eight students.
2. Place the materials around the room so that students can move freely without crossing paths.
3. Prepare for each unit of materials a complete list of supplies for students to use to verify that all supplies are present.
4. Arrange for the use of a car prior to the day the exercise is done.

Procedure

1. Have students read the introduction. Discuss and list on the chalkboard possible causes of the increase of water plants followed by the fish decline. Or, as an alternate procedure, list the requirements of all living things and then discuss which of these requirements could be altered so that the results coincide with the results observed in the lake.
2. Divide each team of eight into two groups. Let one group practice measuring with the pipette using plain water in one 100 ml beaker. Have the other group use the other 100 ml beaker to practice weighing with the balance. When individuals in each group show some proficiency with the apparatus, exchange the instruments between the two groups so that all team members will have had practice in the use of the equipment. The mouthpiece of the pipette should be rinsed in alcohol between use by different persons.
3. Demonstrate how to blot and weigh 10 g of algae.
4. Have teams carry out the procedure through Step 7 in the student manual.

5. Two weeks later have students carry out Procedure Steps 8 and 9 and then complete the interpretation questions.

6. Conduct a discussion centered on the interpretation questions and relating the experiment to the problems of Lake Newburg.

Expected Results

The algae are growing at the top of the beaker. The greater the amount of fertilizer (within the limits of this experiment) the greater the weight of algae produced in two weeks.

Responses to Interpretation Questions

1. The fertilizer increased the growth of algae as measured by algal weight.

2. The leaching of fertilizer from lawns of Newburg probably increased the concentration of fertilizer in the lake. Accumulation by evaporation probably increased the concentration further. This experiment shows that such increase in fertilizer concentration can be expected to increase growth of algae, which in fact, is what happened to Lake Newburg.

3. The oxygen supply in a lake containing a mat of algae would probably be less than the oxygen supply of a lake in which the water surface is not reduced by mats of algae.

4. Algae deplete oxygen at night which is then the time of oxygen crisis for animal life, since all animals require oxygen at all times. A tremendous growth of algae would cut down the amount of oxygen in a lake. Since animals need oxygen to live, with less oxygen the number of animals will decrease.

5. Decaying dead fish release substances that can be used for growth of algae; therefore, they further fertilize lake waters.

6. As fall approaches algae die off not only because of fewer hours of sunlight for growth but especially because of longer nights, which extend the period of oxygen demand.

7. The three main events that occurred in Lake Newburg were a huge growth of water plants, a die-off of fish, and a late summer stench. The first resulted from the leaching of fertilizers into the lake; the second resulted from the depletion of oxygen needed by animals; the third from the seasonal shortening of the hours of sunlight.

Assessment Task

Algae and fish are living in an aquarium that is equipped with an air pump but no source of artificial light. As part of an experiment the light was turned off; then 3 g of fertilizer were added to the aquarium water. In the space provided beside the statements below place numbers to indicate the order in which the described events probably occur.

_____a. The surface of the water becomes covered with an algal mat.

_____b. The algae grow rapidly.

_____c. The night-time supply of oxygen decreases somewhat.

_____d. One night all the fish die.

_____e. The day-time oxygen supply decreases somewhat and the night-time supply decreases greatly.

Acceptable Responses

a. 3
b. 2
c. 1
d. 5
e. 4

FISH IN A BOWL

OBJECTIVES

1. **Demonstrate by use of a controlled experiment, the differences between a polluted and an unpolluted environment.**

2. **Identify the detergent as the agent which causes the death of the goldfish.**

3. **Describe the effects of detergent on goldfish.**

4. **State a rule that the greater the quantity of pollutant the greater the harm to the goldfish.**

5. **Construct a statement that a very small amount of pollutant can produce observable effects on living things.**

6. **Construct a statement that relates the problem of detergent pollution of water to pollution of water by algae and bacteria.**

TEACHING SUGGESTIONS

Preparation

1. **If sufficient materials are available, plan to have students work in pairs. For each student pair prepare a bottle containing approximately 5 ml of a liquid detergent. Bottles with dropper tops are convenient.**

2. **Be sure the beakers are clean and thoroughly rinsed.**

3. **Prepare conditioned water by allowing tap water to stand in a shallow container for at least 24 hours. In this time most of the chlorine will escape. If spring water is available it is preferable.**

4. **Goldfish may be obtained several days in advance. Up to 150 goldfish may be kept alive in a 10 gallon aquarium provided that air is bubbled generously through a plastic tube reaching deep into the tank. Once a day feed the fish as much as can be eaten in several minutes. Overfeeding may result in bacterial contamination.**

Procedure

1. Direct students to read the introduction to "Fish in a Bowl."

2. Referring to a goldfish in a beaker on the demonstration desk, stimulate a discussion to develop the analogy between the fish in a beaker and any aquatic animal in a stream or pond. Remind the students, however, that by working with a model of a much larger system, assumptions regarding cause and effect must be made. (Refer to Mini-Unit B, The Nature of Models.)

3. Distribute materials and have students complete both the procedure and the interpretation questions. Tell students that after the addition of 20 drops of detergent to the beaker containing the experimental fish, the fish in it should be rinsed with cool, running tap water and placed in a separate aquarium. Only the control fish should be replaced in the original tank.

4. Initiate a discussion of the interpretation questions. During the discussion of Interpretation Questions 1 and 2, be certain that students understand the need for the control. The terms control, controlled experiment, and variable, should be defined and applied to the factors in the experiment.

Expected Results

As detergent is added, the experimental fish swims erratically, breathing very rapidly. The gills turn bright red. These symptoms begin after the addition of just a few drops of detergent, and become more apparent with increasing amounts of detergent.

Responses to Interpretation Questions

1. The fish in the container to which no detergent is added shows no adverse effects. All other factors are the same for both fish.

2. The term is control.

3. See Expected Results.

4. This point varies slightly according to the fish but observable changes will probably occur after several drops.

5. Individual students may need some help with the calculation.

6. The general conclusion is that detergents at very low concentrations can produce observable effects on goldfish. At still lower concentrations effects may occur that may not be immediately observable.

7. Detergents, being stable, not only pass through waste water treatment facilities but flow on from small streams to rivers, bays, and oceans.

8. 3,000,000 pints/week x 52 weeks/year = 156,000,000 pints/year;

   156,000,000 pints/year ÷ 8 pints/gallon = 19,500,000 gallons/year.

9. The kind of pollution might be stopped by using only cleaning agents that can be broken down, by refining water treatment procedure, or by prohibiting the sale and use of detergents.

10. Detergents are highly advertised and are thus in great demand.

E-6

WHERE IS NEWBURG?

OBJECTIVES

1. Identify on a map the location of home.
2. Name the bodies of water into which drainage from the home area occurs.
3. Describe the paths of drainage from selected areas of Baltimore County into the Chesapeake Bay.
4. Construct a statement that the pollution of one body of water leads to the pollution of other bodies of water.

TEACHING SUGGESTIONS

Preparation

1. Get out the transparency of Newburg.
2. Make a transparency of the map of Baltimore County.

Procedure

1. Open with the question, "How has Newburg changed so that it now pollutes the environment?" Students will probably suggest that urbanization is the cause of pollution. Follow with the question, "Where is Newburg?" Then have students read the introduction to the investigation.
2. Have students carry out Procedure Step 1.
3. Develop with the class the concept of the water cycle as it applies to pollution, using the transparency of Newburg to aid discussion.
4. Have the students complete Procedure Step 2.
5. Have selected students show their results to the class on the projected transparency of Baltimore County. Then select several places distant from the school's service area and, with student help, trace the drainage patterns from those places.

Expected Results

1. The water that carries the minerals into the lake evaporates from the surface of the lake only to fall again over the land. This demonstrates the water cycle; the arrows drawn by the students indicate this cycle.

2. The responses to A through C will vary according to the location of the students' homes. Surface water from any point in Baltimore County ultimately drains into the Chesapeake Bay. From the farms in northern Baltimore County surface water is carried in the major streams shown on the map. Not all waterways are shown. The rivers polluted by the industries of the southeast are shown on this map. They all drain into the Chesapeake Bay. It is obvious from this study that there is no isolated incident of water pollution. Pollution of one body of water leads ultimately to pollution of the oceans.

Responses to Interpretation Questions

1. DDT is washed from plants into the soil. Then it is leached from the soil into streams. From the streams it flows eventually into the oceans. (The chemical then moves through food chains in the ocean, but this last point is beyond the scope of this investigation.)

2. The bodies of water feeding the Chesapeake Bay pass through many different cities, counties, and states. For example, the 400-mile long Susquehanna River which contributes 52 per cent of the total inflow of surface water, begins at Lake Otsego near Cooperstown, New York.

3. Though the assumption was once a safe one, growth of the human population and especially enormous increase of the pollutants per person, due to industrialization, have, in effect, shrunk the oceans' abilities to dilute pollutants.

4. Many countries share the same oceans or seas. Laws controlling water pollution by any country would protect all others sharing this body of water. For example, England and the United States share the use of the Atlantic Ocean.

Assessment Task

Suppose that your parents would heavily spray a rose garden in your yard with DDT. With the use of your map of Baltimore County, explain how this spraying would eventually contribute to the pollution of the Chesapeake Bay.

DILUTE AND POLLUTE

OBJECTIVES

1. Describe the causes and effects of the pollution of water by sewage.

2. Name bacteria as a principal pollutant in water.

3. Distinguish between polluted and unpolluted water.

4. Demonstrate the method by which the amount of dissolved oxygen is determined.

5. Describe the effects of raw sewage on the dissolved oxygen content of water.

Part A

TEACHING SUGGESTIONS

Preparation

One week prior to student work on this investigation, place the entire contents of one small can of sauerkraut into a large container. Add enough water to allow 100 ml for each student group plus an extra 100 ml for evaporation loss. Cover and place in the dark. Undergoing additional bacterial action, this mixture will serve as the source of "raw sewage" water.

Procedure

1. Have students read the introduction to "Dilute and Pollute."

2. Initiate a discussion to relate the growth of population to the problem of sewage disposal by dilution.

3. Distribute the materials. The odor of the "raw sewage" may be offensive, but inform the students it is not harmful. Nevertheless, have students follow the usual precautions in handling materials that may contain bacteria. Have the students draw the "clean water" from the tap. Caution students not to discard the containers of "raw sewage", which will be used again.

4. Move about the classroom, helping students with the use of the microscope and the identification of the bacteria.

5. At the conclusion of the experiment discuss the results and the interpretation questions. Place the appearance and odor chart on the chalkboard. Have some students sketch bacteria on the chalkboard.

Expected Results

The cloudy appearance and bad odor of the water containing the "raw sewage" are caused by the presence of bacteria. The bacteria are visible under the microscope without staining as light-colored, wiggly rods.

Responses to Interpretation Questions

1. It must be assumed that the bacteria caused the differences in appearance and smell.

2. Bacteria flourish in water containing raw sewage. Although relatively few of the many kinds of bacteria cause human disease, it is just these kinds that are likely to be found in sewage because sewage is derived from human wastes.

3. Since the bacteria consume oxygen you would expect the amount of dissolved oxygen to be less in water containing many bacteria.

Assessment Task

In recent years, Baltimore County health officials have closed several public bathing beaches on Back, Bird, and Middle Rivers, claiming that these rivers are a threat to health. What do you suspect about these rivers? Explain.

Acceptable Responses

The principal implication is the presence of raw sewage in these waters. The source of this contamination has been from adjacent houses without sewage treatment facilities and from overflow from septic tanks.

Part B

TEACHING SUGGESTIONS

Preparation

1. When preparing the solutions, make quantities sufficient for use in both this and the following investigation.

2. Prepare Solution A by dissolving 40 g of hydrated manganous sulfate ($MnSO_4 \cdot 2H_2O$) in 100 ml of water. Divide this into labeled dropper bottles, one for each student group.

3. Prepare Solution B by dissolving 100 g of sodium hydroxide ($NaOH$) in 200 ml of water, then adding 30 g of potassium iodide (KI). Divide into labeled dropper bottles.

4. Prepare Solution C by dissolving 3.1 g of sodium thiosulfate in 1 liter of water. Divide into labeled dropper bottles.

5. Prepare the starch solution by boiling a suspension of 1 tablespoon of corn starch in 200 ml of water. Divide into labeled dropper bottles.

Procedure

1. Initiate a discussion that reminds students of their responses to Interpretation Questions 3 of Part A. Point out that the responses represent hypotheses that this part of the investigation will attempt to support.

2. Distribute materials. Caution the students that this method of oxygen determination is very precise, and thus directions must be followed closely for accurate results.

3. Help students at the beginning of the investigation, but be available to distribute the concentrated sulfuric acid when needed.

CAUTION	Concentrated acid is very corrosive. Avoid contact or breathing of fumes.

4. At the conclusion of the laboratory work, collect from all student groups the data on the number of drops of Solution C needed to clear both the polluted and unpolluted water. Reinforce the idea that Solution C combines with the oxygen, thus changing the color of the water from blue to clear. The more Solution C needed to

clear the color, the more oxygen must be present. Specifically the number of ml of Solution C corresponds to the parts per million (ppm) of dissolved oxygen in the water.

5. Conclude the discussion with a brief consideration of the interpretation questions.

Expected Results

The "clean water" should have more dissolved oxygen than the raw sewage. This is indicated by the fact that more Solution C is required to clear the unpolluted water.

Responses to Interpretation Questions

1. You might suspect that parts of the Patapsco River have been polluted by raw sewage.
2. Students should answer, "To replace oxygen used by the bacteria." Actually, the principal purpose of this step in sewage treatment is to kill or inactivate anaeorbic bacteria by exposing them to excess oxygen. This question provides you with an opportunity to show that a perfectly logical conclusion can be erroneous if the data on which the conclusion is based are insufficient.
3. Graph B
4. Graph C
5. Pollution by raw sewage is considered undesirable esthetically; that is, it looks and smells bad. It also promotes the growth of bacteria that deplete oxygen and thus cause the death of other forms of aquatic life. Raw sewage also contains disease-producing bacteria.

Assessment Task

Most detergents are rich in phosphates, which stimulate the growth of algae. The algae grow so rapidly that many times they suffocate themselves. Thus lakes may become clogged with dead algae. In the light of the experiment you have just done, explain how our home-cleaning habits influence the amount of oxygen available to aquatic life forms.

Acceptable Response

The dead algae are a source of food for bacterial. Increase in dead algae therefore results in an increase in the population of bacteria. Increase in the population of bacteria increases use of oxygen, thus decreasing the oxygen supply in the lake water.

WARM UP

OBJECTIVES

1. Demonstrate the release of gases from water as temperature increases.
2. State the rule that as the temperature of water increases the amounts of dissolved gases decrease.
3. Demonstrate a procedure for determining the amount of oxygen in water.
4. Construct a statement relating the number of power plants in an area to the amount of dissolved oxygen in the water.
5. Identify the location of existing and proposed power plants in the Chesapeake Bay region.

Part A

TEACHING SUGGESTIONS

Procedure

1. Have students read the introduction. Then initiate a short discussion on the possible effects of releasing heated water into the Chesapeake Bay. During this discussion attempt to elicit hypotheses from the students with a minimum of comment and no attempt at evaluation of the ideas expressed.
2. Distribute materials. Caution students not to bring the water to a boil. Also caution them not to point the test tubes toward themselves or anyone else.

Expected Results

As the temperature of the water increases, gases in solution are liberated. The gases form bubbles that cling to the sides of the heated test tube and, when the tube is tapped, the gas bubbles come to the surface and break.

Responses to Interpretation Questions

1. As temperature is raised gases dissolved in water escape. This should be re-phrased for students "Cooler water can hold more dissolved gases than warm water."

2. Although several tenable reasons might be given, the one most closely related to the experiment is the possibility that the organisms died from lack of dissolved oxygen.

Part B

TEACHING SUGGESTIONS

Preparation

1. If sufficient solutions for the Winkler test are not left from the previous investigation prepare new stocks. For directions, see Investigation E-7.

2. Heat enough water in a large beaker to provide 100 ml for each student group. Heat the water for approximately 15 minutes, but do not boil. Avoid agitation of this water after heating.

Procedure

1. Introduce the experiment by reviewing both the effect of temperature on gas solubility and the relationship of gas content of water to aquatic life.

2. Distribute materials. Remind students that the procedure is the same as that used in Investigation E-7.

3. At the conclusion of the laboratory work use the chalkboard to record data from all groups. From this data, establish the relationship between the temperature of water and its dissolved oxygen content.

Expected Results

The heated water has less dissolved oxygen than the unheated water.

Responses to Interpretation Questions

1. The fish placed in the cool, unboiled water has the best chance of survival, since the unboiled water has the higher content of dissolved oxygen.

2. Some kinds of fish, such as suckers, need less oxygen than others, such as trout.

3. The containers in order from least to most oxygen are: 1st: 45° C; 2nd: 38°C; 3rd: 18°C; 4th: 15°C; 5th: 10°C.

4. The combination of high water temperature and high phosphate content in the water has caused very rapid growth of algae in many areas.

Part C

TEACHING SUGGESTIONS

Preparation

1. Prepare a transparency of the map of existing and proposed power plants in the Chesapeake Bay region. If you do not have a chalkboard grid, prepare a transparency of one.

2. Prepare duplicated copies of the map in a quantity sufficient for a copy per student.

Procedure

1. Have students review the introductory paragraphs

2. Distribute copies of the map and have students complete the work in the student manual.

3. Use the overhead transparency of the map to clarify points made during the summary discussion. A chalkboard grid or a transparency grid will be useful for checking the students' graphs.

Expected Results

1. The power plants are all located on the shores of bodies of water.

2. The plants need the water to cool the nuclear reactors or in the case of conventional power plants, the stream.

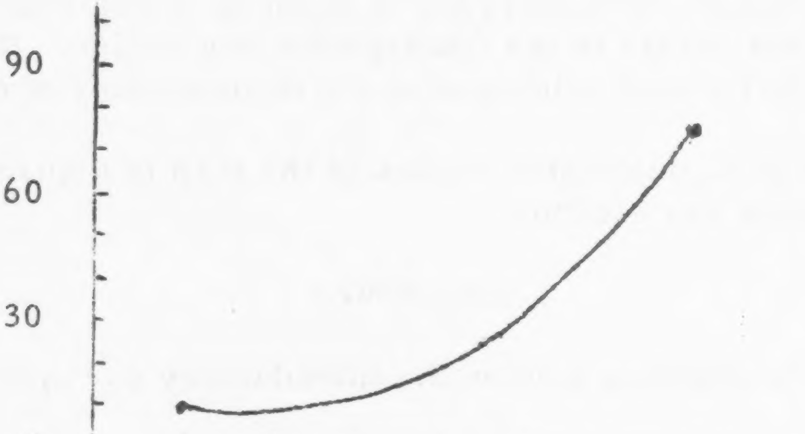
3. These rivers are important to the Chesapeake Bay because they empty fresh water into the Bay and help to maintain water circulation.

4. The best assumption is that all the events resulted from the increase in temperature, since this is the only identifiable variable. Of course, the evidence is not conclusive in any of the cases.

Responses to Interpretation Questions

1. Because of the very large part played in Maryland's economy by the harvest of aquatic animals-- particularly oysters, crabs, clams, and finfish-- and by the businesses supported by sports fisheries, any threat, such as thermal pollution, to the welfare of aquatic animals of the Chesapeake will have an effect on that economy.

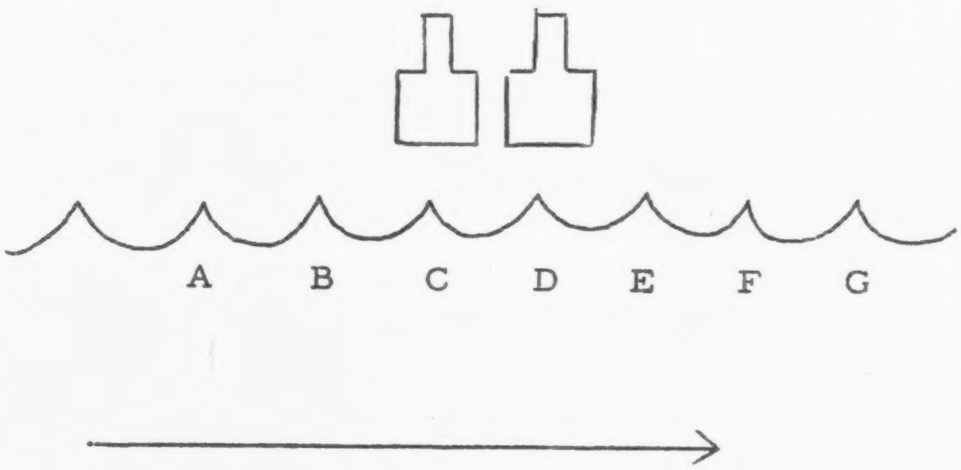
2. The graph should appear roughly as follows:



3. Lack of evidence is no support for a conclusion either way. And, of course, the word "safe" has no quantitative meaning. The student has already seen in the discussion of Interpretation Question 2 in Part B that different kinds of fish have differnt oxygen requirements.

Assessment Task

Each letter in the diagram below represents a location along a river. The locations are one mile apart. At Points C and D are power plants using the water to cool their reactors. The water is flowing in the direction of the arrow. If you were going to select a location along this river for fishing, where should it be? Why?



Acceptable Response

The best location would be at Point A. It is the most distant point from the power plants in the direction opposite to the flow of the water. The water would be coolest here; thus it would have the most dissolved oxygen and would support the most sport fish, which in general, require large amounts of oxygen.

SLICKER AND SICKER

OBJECTIVES

1. State a rule that oil is less dense than water, and thus floats on the surface of the water.

2. Construct methods for removing oil from the surface of the water.

3. Demonstrate absorption, burning, and dispersal methods for removing oil from the surface of water.

4. Describe the effect of various materials on oil.

5. Distinguish between effective and ineffective or practical and impractical methods of removing oil from the surface of the water.

Part A

TEACHING SUGGESTIONS

Preparation

1. Prepare one dropper bottle per student group containing 5 ml of heavy motor oil purchased at a gas station. It need not be new. Do not use machine oil.

2. For each student group prepare a dropper bottle containing 5 ml of methyl alcohol.

3. Prepare non-absorbent cotton pieces roughly 2 cm across.

4. Cut pieces of porous styrofoam balls. Do not use the compressed kind that is used in drinking cups. The pieces should be approximately the same size as the cotton pieces.

5. Obtain the liquid detergent; any type of liquid detergent can be used.

Procedure

1. Direct students to read the introduction of the investigation and to find specific figures that show the volume of oil used and the volume spilled.

2. Initiate a short discussion in which students are encouraged to relate their personal knowledge of specific incidents of oil pollution and the problems they caused.

3. Distribute the first three items of the materials. Have students complete Procedure Step 3. Then have Procedure Step 4 read aloud in order to emphasize the importance of each student's ideas.

4. Allow sufficient time for students to complete Procedure Step 4 before initiating a discussion of the students' ideas. Make the discussion as exciting as possible; call upon students to defend their ideas as well as to comment on the ideas of others. List, on the chalkboard, the ideas as they are presented. You may want to classify the suggested methods as either chemical or physical.

Expected Results

Being lighter than the water, the oil floats. It forms globules because it coheres to itself. The water also shows great cohesion and excludes the oil. The oil does not react with the water either chemically or physically.

Assessment Task

Spilled oil floats and sticks to itself. Although nobody wants oil spills, it is fortunate that oil has the physical properties it does. Why is this true?

Acceptable Responses

Since it is less dense than water, it floats. Since it coheres, it remains connected. Both of these characteristics make it easier to remove or treat spills than would be the case if oil sank or easily scattered.

Part B

TEACHING SUGGESTIONS

Procedure

1. Caution students to be very observant as to the effectiveness of the various methods in removing the oil or in changing it so that it is easier to remove.

2. Distribute materials. Have students complete the procedure and the interpretation questions.

Expected Results

1. Oil is difficult to remove with a medicine dropper. A mixture of both oil and water is taken into the dropper.

2. The paper towel soaks up oil and water. This method is very "sloppy" and cumbersome.

3. The cotton is quite effective in absorbing the oil. The non-absorbent cotton is coated with an oil film to which the oil in the water coheres.

4. The flame goes out.

5. The small pieces of paper towel absorb oil; however, the paper disintegrates, sinks, and is "sloppy."

6. The straw absorbs oil well, and is easy to remove.

7. Styrofoam soaks up the oil.

8. The match stays lit on the styrofoam. The flame is fed by the oil vaporizing from the surface of the styrofoam.

9. The oil is dispersed by the alcohol, but comes together again when the alcohol mixes with the water.

10. The detergent disperses some of the oil droplets to the bottom of the beaker. The oil carried to the bottom will return to the surface.

Responses to Interpretation Questions

1. Chart

Method	Why This Might Work	Why This Might Not Work
Using eyedropper	Does remove oil.	Too difficult on a large scale; gathers water as well as oil.
Removing with paper towel	Paper does absorb oil.	Is too difficult, impractical, and expensive.
Touching lighted match to oil	Oil can be burned off with a very hot flame.	Is impractical; causes pollution of air.
Removing with small pieces of paper towel	Paper does absorb oil.	Is impractical, expensive.
Removing with straw	Does absorb oil, floats, and is easily removed.	Is difficult to deploy and retrieve over large area.
Removing with styrofoam	Is same as for straw.	Is same as for straw.
Burning with s styrofoam	Provides burning point for oil vapor.	Is impractical, expensive, and pollutes air.
Adding alcohol	Has no value.	Alcohol mixes with water.
Adding detergent	Disperses or sinks oil	Oil coheres again or returns to surface; pollutes water.

2. Oil is less dense than water. It floats on the surface of water.

3. Floating oil does not easily vaporize; there is a limited area of contact between oil molecules and oxygen molecules. Given an irregular surface from which it can vaporize, oil burns well.

4. They both absorb oil well, are relatively inexpensive, and do not easily disintegrate.

5. No, this is not a good method because it does not remove oil. It merely disperses or sinks the oil. Especially in the latter case, aquatic life may be destroyed.

6. Burning removes oil pollution but adds to air pollution.

7. Since the oil stays together, it can be contained in one spot or moved to another.

8. The oil can be dispersed into droplets (emulsified) by a detergent. Eventually bacteria consume such dispersed oil, but the process is slow and great damage to aquatic life may occur in the meantime.

9. Some regulations might be: limiting size of ships; assessing large fines for carelessness; tagging oil with a radio-active substance as a means of identifying culprits; requiring ships to carry equipment to deal immediately with oil spills.

SOMETHING ABOUT GASES

OBJECTIVES

1. State a rule that relates the temperature of a liquid to the amount of gas that can dissolve in it.
2. Order the color changes in bromthymol blue as the dissolved carbon dioxide in the liquid containing it either increases or decreases in concentration.

Part A

TEACHING SUGGESTIONS

Preparation

Prepare for the demonstration as follows:

1. Get two identical bottles of any kind of soft drink.
2. Put one of the bottles in a warm place overnight.
3. Put the other bottle in the refrigerator overnight.

CAUTION: Do not put the bottle in the freezing compartment of the refrigerator to chill it. The bottle may break.

4. Get two rubber balloons of the same size.
5. Uncap both sodas at approximately the same time and recap each with a balloon. Make large labels, "Warm" and "Cold" and attach them to the appropriate bottles.

Procedure

1. Read the introduction to the investigation. Follow this with a brief student-centered discussion concerning: (1) effects of an increase in cars on the gases in the atmosphere; (2) probable kinds of substances in automobile exhaust gases; and (3) possible effects of automobile exhaust gases on people who may breathe them. Why is it inadvisable to run a car engine in an enclosed garage?

2. Place the two balloon-capped bottles on the demonstration desk. Invite individual students to come to the demonstration desk to feel and examine the two set-ups. Have students complete Procedure Step 1 in their manuals.

3. The following day have students observe the bottles again and complete Part A in their manuals.

4. After a brief discussion of the interpretation questions, proceed to Part B.

Expected Results

On the second day the balloon on the bottle that was warm may be a little more distended than it was on the first day. On the second day the balloon on the bottle that was cold should be quite distended.

Responses to Interpretation Questions

1. Since the balloons were tightly fastened to the bottles, the only source of gases to distend them was the liquid that the bottles contained. Since, in fact, the balloons did become distended with gas, the gas must have been dissolved in the liquid.

2. When warmed, more gas came from the previously cold liquid than from the liquid that was already warm. This indicates that the cold liquid contained more dissolved gas than did the warm liquid.

3. The colder a liquid, the greater the volume of gas that can be dissolved in it.

Part B

TEACHING SUGGESTIONS

Preparation

1. Obtain large test tubes, preferably 25 x 200 mm. Because color changes are most discernible against a white background use white drinking straws.

2. For the demonstration obtain a bottle of soft drink. Put a piece of glass tubing into a 1-hole stopper that will fit the soft-drink bottle. Attach a short piece of rubber hose to the glass tubing.

Procedure

1. Pose the question, "How can you tell what kind of gas is in the soft drink?" Some students probably know what the gas is, but insist on a way to distinguish the gas from plain air. Define "indicator" as a substance that shows by some change (usually in color) the presence of another substance.

2. Distribute the materials for Part B and have students carry out the procedure.

3. Before students proceed with work on the interpretation questions, perform the following demonstration:

   Open a cold bottle of soft drink. Quickly insert the previously prepared stopper assembly. Gently warm the bottle (holding in the hands will do) and bubble the gas that comes from the rubber tubing through a test tube containing water colored with bromthymol blue.

4. After students have had an opportunity to work on the interpretation questions, conduct a brief class discussion, emphasizing the final question.

Expected Results

The colors observed are, in the order of appearance: blue, blue-green, green, yellow-green, yellow. The tube that is merely exposed to air should remain blue.

Responses to Interpretation Questions

1. Bromthymol blue indicated the presence of some substance in the breath, because the liquid in the tube into which breath was blown changed colors as the amount of breath was increased, while the liquid in the tube into which no breath was blown remained blue.

2. The gas indicated by bromthymol blue is carbon dioxide. Many students will recall that carbon dioxide is in exhaled air and some will have heard that the carbonation in soft drinks derives from carbon dioxide. Of course, bromthymol blue is not a specific indicator of carbon dioxide (as students will see later), so the presence of carbon dioxide has not been "proved."

3. a. Blue is the color indicating the least concentration of the gas in water.

   b. Yellow is the color indicating the greatest concentration of the gas in water.

   c. Green is the color indicating a medium concentration of the gas in water.

4. To increase the concentration of dissolved gas the water might have been made very cold. As students saw in Part A, more gas dissolves in cold water than in warm water.

5. There are many possible responses to this question. Experience in this investigation, however, should suggest some device for bubbling the exhaust gases through cold water.

Assessment Task

A cold colorless soft drink was uncapped and bromthymol blue was added to it. If the liquid remained on the windowsill in the sun all day, in what order should the indicator colors appear? Give reasons for your answers.

Acceptable Response

The color sequences observed in the warming liquid should be: yellow, yellow-green, green, green-blue, and blue. As it warms, the soda gives off carbon dioxide. The indicator shows a decrease in the carbon dioxide as the liquid warmed.

E-11

ARE YOU SURE?

OBJECTIVES

1. Name hydrogen as the element that must be present in all acids.
2. Demonstrate a technique used to identify an acid.

Part A

TEACHING SUGGESTIONS

Procedure

1. Introduce the investigation by reviewing the plans presented for collecting automobile exhaust gas. Show the class the assembled apparatus.
2. Select two students to be the active members who collect the gas in the container of water. If possible, have the whole class observe the procedure. Otherwise have the students who do the actual collection report to the class on their work.

Part B

TEACHING SUGGESTIONS

Preparation

1. Check the tap water with bromthymol blue. If it does not produce a good blue color, let it stand over night.
2. Locate the materials so that the traffic pattern presents few obstacles. For example, place containers of water containing exhaust gases near the tap.

CAUTION: Have students keep all glassware at the back of the desk to avoid breakage due to general arm movement.

Procedure

1. Introduce the investigation by referring to the use of bromthymol blue as an indicator of a gas. A question such as, "Will bromthymol blue indicate the gas we have collected from an automobile exhaust?" can lead into the experiment.

2. Distribute the materials for the investigation. Personally distribute materials that may easily be broken; for example, the 25 ml graduates.

3. As students begin work, circulate through the laboratory. Have students verify that they can read the meniscus of the graduated cylinder by checking their first reading.

4. Conduct a brief discussion of the interpretation questions before proceeding to Part C.

Expected Results

The colors that should appear in the beakers are:

Beaker 1.	yellow-green
Beaker 2.	light green
Beaker 3.	dark green
Beaker 4.	blue-green
Beaker 5.	blue

Responses to Interpretation Questions

1. Plain tap water was used in Beaker 5 to obtain a standard (control) as a guide for observing color changes.

2. The color of the indicator in the control beaker of tap water was different from the colors in the beakers containing water through which exhaust gases had passed. Moreover, the color difference was greater the larger the amount of exhaust-gas water.

3. Since even the liquids containing diluted exhaust-gas water showed a color change when the indicator was added, it would appear that there was much exhaust gas dissolved in the water.

4. Since the color changes of bromthymol blue in solutions containing exhaust gases were the same as the color changes observed in the previous investigation it is possible to conclude that carbon dioxide gas is present in exhaust gases. Moreover, some students may recall the correspondence between human body processes and burning. But caution students about overconfidence in the evidence assembled so far.

Part C

TEACHING SUGGESTIONS

Preparation

1. Obtain 0.1 M solutions of HCl, HNO_3, and H_2SO_4.

2. Get a piece of white poster board and devise a means of supporting it behind the beakers so that colors show distinctly.

Procedure

1. Perform the following demonstration:

   Mark five 400 ml beakers with the formulas indicated in the student manual, Page 49. Place them against a white background and in an elevated position so that all students can see them clearly. Add several drops of bromthymol blue to each beaker.

2. Discuss the colors observed so that a reasonable degree of class agreement is obtained.

3. Have students complete the procedure and interpretation items in their manuals. Keep each beaker in sight to reinforce the similarity of the color.

4. Summarize the investigation with a discussion of the interpretation questions.

Expected Results

The color in all the beakers should be yellow. All the formulas contain the symbol H for hydrogen.

Responses to Interpretation Questions

1. The color changes observed in the demonstration were the same as the color changes observed in both the water containing exhaust gases and the water that was breathed through.

2. The general name for all liquids used in the demonstration is acid.

3. Since bromthymol blue changed to yellow in five different acids, bromthymol blue is apparently an indicator for acids.

4. Because carbon dioxide in water showed the same color changes with bromthymol blue as acids did, perhaps carbon dioxide somehow makes water an acid.

5. The student cannot be really sure of very much. Probably the greatest confidence can be placed in the reaction of bromthymol blue to acids since the same reaction was observed in five different acids -- provided the student has confidence in the teacher's identification of the acids. Next, it seems fairly sure that "something" in the breath is probably carbon dioxide. The "something" in the exhaust gases may be carbon dioxide; or it may not be; or it may be carbon dioxide plus something else.

Assessment Task

Bromthymol blue was added to a clear liquid. This liquid turned a bright yellow. One of the following compounds is known to be in the liquid: $Ca(OH)_2$; CH_4; HF; NO_2; NaCl. Which is the most likely compound in the liquid?

Acceptable Response

The most likely compound is HF, hydrofluoric acid. Other formulas contain hydrogen, but in each of the formulas for acids on Page 49 of the student manual an H came first, even when (as in acetic acid) other H's occurred later in the formula.

E-12

MEASURING ACID CONCENTRATION

OBJECTIVES

1. Identify the hydrogen ion as the first ion written in the formulas of acids.

2. Order the pH numbers of acids from pH 1 to pH 7.

3. Using pH paper, identify familiar household substances as acids.

MATERIALS

beakers, 1000 ml, 2
stirring rods, 2
hydrochloric acid, 0.1 M
Universal Indicator

TEACHING SUGGESTIONS

Preparation

1. Thoroughly rinse the two 1000 ml beakers. Soap residue on glass gives a basic reaction.

2. Check the tap water with Universal Indicator. If it is not distinctly yellow-green, obtain distilled water.

3. Prepare a 0.1 M HCl solution by pouring 83 ml of a 12 M solution of hydrochloric acid (commercial strength) into enough water to make one liter.

Procedure

1. Introduce the investigation by recalling Interpretation Question 3 from Page 45 of the student manual. Point out that students have now seen that the colors of bromthymol blue are rough measures of the concentration of acid. However, the color changes of bromthymol blue are too narrow (blue ⟶ green ⟶ yellow) to provide a measure of the full range of acid concentrations.

2. Perform the following demonstration:

   a. Put 100 ml of water in a beaker. Add about 10 drops of Universal Indicator. Allow students to observe the color against a white background. Add 100 ml of water and stir. Hold the beaker up for observation. Continue adding water in 100 ml amounts until the beaker is filled. Stir after each addition and hold up for student observation.

   b. In the second beaker place 100 ml of 0.1 M hydrochloric acid. Add Universal Indicator and proceed in the same way that was described for the water.

Expected Results

The color of Universal Indicator in distilled water (neutral) should be yellow-green; in the 0.1 M acid it should be red. Water in the first beaker should show no change of hue; the color merely becomes paler by dilution. Acid in the second beaker should show the following sequence of color changes: red, orange-red, orange, yellow, yellow-green.

Responses to Interpretation Questions

1. All acids produce the same color changes when Universal Indicator is used. The student's answer is based on the evidence obtained in noting identical color changes of bromthymol blue with 5 different acids.

2. Hydrogen is written first in the formula for an acid, even though additional hydrogen atoms may be indicated in following parts of the formula.

3. The ions of the formulas would be:

   H^+Cl^-
   $H^+(COOH)^-$
   $H^+(NO_3)^-$
   H^+Br^-
   H^+I^-
   $H^+(HCO_3)^-$

4. The H^+ ions are the only ions common to all acids; therefore, it must be the H^+ ions that produce the color changes.

5. When water was added to water plus indicator, the color of the indicator did not change.

6. The only answer readily available to an unsophisticated student is that there are too few H^+ ions to produce a color change.

7. a. The pH would not change if table salt were added to the water. Since the pH of water is 7, the pH of table salt and water would be 7.

   b. Because addition of HCl increases the hydrogen ion concentration, the acidity would increase; therefore, the pH number would decrease.

8. distilled water ← 7 6 5 4 3 2 1 → most concentrated acid

9. pH 4.0: red
   pH 5.0: orange-red
   pH 6.0: orange
   pH 6.5: yellow
   pH 7.0: yellow-green

10. Dilution increases the pH number; i.e., reduces the acid concentration.

Part B

TEACHING SUGGESTIONS

Preparation

1. Cut pH paper into 2 cm strips. For each student group put ten or more of these strips into a small container such as a baby food jar or a 50 ml beaker.

2. For each student group prepare a set of samples of the substances to be tested. The samples can be contained in small vials.

3. Check the pH of each substance, using the pH paper that the students will use.

Procedure

1. Ask the question, "Do familiar household substances contain acids?" Several suggestions should be received. Ask, "How can you determine how concentrated the acids are?" Have students read the introduction to Part B in the student manual.

Point out the color scale provided with the pH paper.

2. Distribute the materials. Have students complete the investigation, including the interpretation questions.

3. Have one student from each group record the observed pH numbers for his group on the chalkboard so that other groups can compare their results.

4. Conclude with a summary discussion based on the interpretation questions.

Expected Results

The following results are typical, but variation is to be expected:

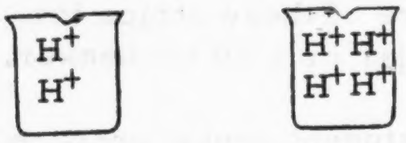
lemon juice:	pH 3
orange juice:	pH 3
vinegar:	pH 2
pineapple juice:	pH 3
tap water:	pH 7

Responses to Interpretation Questions

1. Most of the acid substances that we eat contain rather dilute acids. Although vinegar and lemon juice have fairly low pH's these substances are usually diluted in foods.

2. The vinegar should have the lowest pH; therefore, it has the greatest concentration of hydrogen ions.

3.



4. A concentrated acid has more H^+ ions in the same volume than a dilute acid has.

E-13

ACID ACTION

OBJECTIVES

1. Describe the process of neutralizing an acid by adding a metal to it.

2. State the rule that hydrogen ions will be replaced more quickly in concentrated acid than diluted acid.

Part A

TEACHING SUGGESTIONS

Preparation

1. Prepare a 0.1 M HCl solution by pouring 83 ml of a 12 M solution of hydrochloric acid (commercial strength) into enough water to make one liter.

2. Select for use in this investigation marble chips that are approximately, all of the same size.

3. Note that Part A requires a week of waiting; plan accordingly.

Procedure

1. Briefly discuss such processes as erosion of land, wearing of metals, and weathering of statues and monuments. Ask students to consider how such destructive processes occur. Accept without comment all suggestions. Among them the destructive action of acids is almost certain to occur.

2. While the class observes, pour 10 ml of 0.1 M HCl solution into 90 ml of water. (Note that students are to refer to the 0.1 M acid as "concentrated.")

3. Distribute materials. Because reactions with the marble chips are more observable against black, have students put the beakers on the black top of the desk.

4. Provide time on Day 2 for students to check the pH's in their two beakers.

5. On Day 7 have students complete the procedure of Part A and answer the interpretation questions.

6. Conduct a discussion of the interpretation questions emphasizing logical thinking from evidence to conclusions.

Expected Results

1. The dilute HCl will be one-tenth as concentrated as the original acid because the hydrogen ions in 10 ml were spread out in 100 ml. Since the dilute acid is one-tenth as concentrated as the acid having 100 H^+ ions in 10 ml, the dilute acid will have one-tenth, or 10 H^+ ions per 10 ml.

2. The data in the students' chart will vary except for the following generalizations:

    a. The beaker containing the marble chip and the concentrated acid will show bubbles, while the beaker with the marble chip and the dilute acid will not.

    b. On the second day the pH of the solution in the beaker that originally contained concentrated acid should still be lower than the pH of the solution in the beaker that originally contained the dilute acid.

    c. On the seventh day the pH of the solutions in both beakers should be approximately the same.

    d. The sizes of both chips should be smaller at the end of the seventh day than they were on the first.

Responses to Interpretation Questions

1. Between the first and last pH reading of the concentrated acid the pH number increases. This indicates a decrease in the hydrogen ion concentration.

2. In the dilute acid the pH number also increased (though perhaps not as much), so the hydrogen ion concentration decreased in that acid, too.

3. A gas bubbled up around the marble chip in the concentrated acid. In both acids the marble chips decreased in size during the week.

4. The bubbling in the concentrated acid and the lack of bubbling in the dilute acid seem to indicate that the speed with which a reaction between an acid and marble takes place is determined by the concentration of the hydrogen ions.

5. Volume for volume, the concentrated acid has more hydrogen ions than the dilute acid.

6. Acid will act on marble as long as there are any hydrogen ions present in the liquid.

7. The dilute acid did not show any evidence that the acid was reacting on the marble because the reaction was so very slow.

8. Marble chips in acid decreased in size and became smoother. Both the decrease in size and the increased smoothness indicate that acid acted on the marble. Automobile exhaust gases in water produce the same color change in bromthymol blue that acids produce.

Part B

TEACHIGN SUGGESTICNS

Preparation

1. Cut magnesium ribbon into strips about 3 cm long. Put 5 magnesium strips in a container as was done for distributing pH paper strips in Investigation 12.

2. Prepare 0.1 M hydrochloric acid and fill enough small reagent bottles so that each student group may have one bottle.

Procedure

1. Recall the reaction of marble and hydrochloric acid. This can be done to some degree even if the final results of Part A have not been obtained since a very visible reaction was noted in the concentrated acid the first day. Pose the question, "Will metals react with an acid as marble does?"

2. Distribute the materials. Have students carry out the procedure and complete the interpretation questions.

3. Base the summarizing discussion on the reasoning processes called for by the interpretation questions.

Expected Results

When magnesium ribbon is put in concentrated acid, bubbles rise and the ribbon disintegrates. When so much magnesium ribbon has been placed into acid that no further reaction is visible the pH should be approximately 7.

Responses to Interpretation Questions

1. The pH increased nearly to that of plain water. This means that the concentration of hydrogen ions went nearly to zero. Perhaps the hydorgen ions were changed to hydrogen and escaped from the liquid. The element hydrogen must have been removed from the liquid.

2. A gas bubbled from the liquid. The element hydrogen is a gas. This further supports the above conclusion.

3. Magnesium must have become a part of the liquid because it disappeared into the liquid and there is no reason to suppose that it escaped as a gas.

4. Magnesium replaced the hydrogen in hydrochloric acid.

5. A pH of 7 indicates that a liquid is not an acid.

6. The reasoning is the same as for Item 8 in the interpretation of Part A. In solution, gases form acids and acids react with metals, reducing them to soluble substances -- or, as in the case of rust, to friable substances the particles of which can be washed away.

Assessment Task

Workmen had a choice of the following materials for removing a thin metal coating from a casting

1. a detergent
2. scouring powder
3. sand paper
4. HCl: pH 5
5. $H(NO_3)$: pH 2
6. turpentine

If the workmen must clean the casting in a day without damaging the casting, which material should they use? Why?

Acceptable Response

The workmen should use HCl at pH 5 because the weak acid would react with the metal so slowly that the amount of reaction could be controlled. $H(NO_3)$ at pH 3 would react too rapidly. The other cleansers require too much time and energy (sandpaper and scouring powder) or would be completely ineffective on metal (detergent and turpentine).

COMBATING ACID DAMAGE

OBJECTIVES

1. **Distinguish between the formulas for acids and bases.**

2. **Demonstrate the production of a salt and water from the reaction of an acid and a base.**

3. **Identify some common household products as either acidic or basic.**

Part A

TEACHING SUGGESTIONS

Preparation

1. **Prepare a O.1 M solution of hydrochloric acid by pouring 83 ml of a 12 M solution of hydrochloric acid into enough water to make one liter.**

2. **Prepare a O.1 M solution of sodium hydroxide by dissolving 4 g of sodium hydroxide in one liter of water.**

3. **Cut enough 3 cm strips of pH paper so that each student group has ten pieces. Place the strips for each group in a separate 50 ml beaker, baby food jar, or similar container.**

4. **Because the pH of tap water differs from place to place and from one time to another, the number of drops to be used in each step of the procedure has been left blank in the student manual. The approximate numbers of drops are:**

   Step 3: 30 drops,

   Step 4: 30 drops,

   Step 5: 7 drops.

   Using the solutions you have prepared, try out the students' procedure prior to requesting the students to do it. Modify the number of drops to fit the expected results (See next page.) according to your experience with your own solutions.

Procedure

1. Have students read the introduction. Conduct a brief student discussion on the questions posed there.

2. Have students read through the procedure. Write on the chalkboard the numbers of drops you have decided upon for Procedure Steps 3, 4, and 5. Have students fill the blanks in their manuals with this information.

3. Present the following cautions:

   a. After each use place the medicine dropper on the watch glass so that the dropper end does not touch the table. Otherwise the dropper may become contaminated and the table may be scarred.

   b. Do not use the medicine dropper for anything but the sodium hydroxide. Results will be unreliable if the dropper is contaminated by substances other than NaOH.

   c. Put used pH paper on a paper towel for eventual disposal. The wet pH paper may scar the table.

   d. In Procedure Step 5 be sure to check the pH with every two drop addition because the pH will be changing rapidly.

4. Distribute the materials. Have students complete both the procedure and the interpretation.

5. Conduct a class discussion of the results and the interpretation questions.

Expected Results

The pH readings expected in the chart are:

Step 2: pH 1 or pH 2

Step 3: pH 3 or pH 4

Step 4: pH 5 or pH 6

Step 5: pH 7

Responses to Interpretation Questions

1. The solution became less acid as sodium hydroxide was added. The evidence is that the pH numbers became larger.

2. The H^+ ions decreased in number. The evidence is the increase in observed pH.

3. The $(OH)^-$ ion keeps water from showing an acid pH.

4. The $(OH)^-$ ion of sodium hydroxide might act like the $(OH)^-$ ion of water to balance the H^+ ions.

5. H^+ [from acid] + $(OH)^-$[from sodium hydroxide]$\rightarrow H^+(OH)^-$[water]

6. $H^+Cl^- + Na^+(OH)^-$ produced $Na^+Cl^- + H^+(OH)^-$.

7. Any acid plus sodium hydroxide produces water plus a salt.

8. The following formulas should have a single line beneath them:

   $\underline{\text{NaOH}}$ $\underline{\text{LiOH}}$

   $\underline{\text{KOH}}$ $\underline{\text{NH}_4\text{OH}}$

9. The following formulas should have a double line beneath them:

   $\underline{\underline{\text{HCl}}}$ $\underline{\underline{\text{H}_2\text{SO}_4}}$ $\underline{\underline{\text{HNO}_3}}$ $\underline{\underline{\text{HBr}}}$

10. 100 molecules of hydrochloric acid require 100 molecules of sodium hydroxide to neutralize them. Each hydrochloric acid molecule contains one H^+ ion and each sodium hydroxide molecule contains one $(OH)^-$ ion; one H^+ exactly neutralizes one $(OH)^-$.

11. The pH from the above reaction would be 7.

12. Water is neutral because each of its molecules contains one H^+ ion and one $(OH)^-$ ion. Each cancels out the other.

13. a. Hydrogen bubbled from the solution when a metal was added to an acid.

    b. The solution was less acidic because the number of hydrogen ions was reduced.

14. The acidity of a solution can be reduced by:

    a. putting a metal in the acid.

    b. putting a base with the acids.

15. Damage to a marble statue might be reduced by washing with water--that is, by greatly diluting the acid (See Investigation E-12, Part A.). Or, a weak base might be poured on the acid.

Part B

MATERIALS

Preparation

1. Prepare a 0.1 M solution of sodium hydroxide as you did for Part A.

2. Try out the demonstration before performing it for the students.

Procedure

1. So that all students may see, perform the entire demonstration on a platform raised above the level of the demonstration desk. Keep a piece of white poster board behind the beaker because the colors are difficult to see when the background is dark.

2. Into a beaker containing 400 ml of tap water put 100 ml of 0.1 M NaOH. Add about 10 drops of Universal Indicator. Stir. Have students record the color.

3. Transfer 100 ml of the above solution to a second beaker. Add 400 ml of tap water. Rinse the first beaker. Transfer 100 ml of the diluted solution back to the first beaker. Add to it 400 ml of water--a second dilution. Add enough of the Universal Indicator to show a pronounced color. Stir. Have students record the color.

4. Transfer 400 ml of the final solution of Step 3 to the rinsed second beaker. Add 400 ml of water and enough Universal Indicator to show a pronounced color. Stir. Have students record the color.

5. Transfer 400 ml of the solution from Step 4 to the rinsed first beaker. Add 100 ml of water and sufficient indicator to show a pronounced color. Stir. Have students record the color.

Expected Results

Step 2: violet, pH 9.5

Step 3: blue, pH 9.0

Step 4: blue-green, pH 8.5

Step 5: green, pH 7.5

Responses to Interpretation Questions

1. The ion in solution that is being diluted is the $(OH)^-$ ion.

2. a. As a base becomes weaker, the pH number becomes smaller.

   b. As an acid becomes weaker, the pH number becomes larger.

3.

pH 14	pH 7	pH 1
Base	Neutral	Acid

Part C

TEACHING SUGGESTIONS

Preparation

For each student group prepare a set of vials containing the materials to be tested. Label each vial so that the contents are readily identified.

Procedure

1. Recall from Investigation E-12 that substances containing acids may be found in the home. Have students name some examples such as vinegar, lemon juice, and pineapple juice. State that bases are also found in places other than in the chemistry laboratory. Ask students to suggest some basic substances that might be found in the home. The chances of having the students name any common, household base are few.

2. Distribute the materials and have students complete both the procedure and the interpretation questions.

3. The summarizing discussion should be brief, since Part C is not on the main track of the unit.

Expected Results

Solution	pH	Acid or Base
Borax	9	Base
Household ammonia	11	Base
Soap	9	Base
Drain cleaner	13	Base
Milk of magnesia	10	Base

Responses to Interpretation Questions

1. Any of the solutions could be used to neutralize vinegar. In general, however, a weak acid is preferably treated with a weak base.

2. Soap could neutralize any acid; since it is itself a base, it could not neutralize another base.

3. The pH of any liquid can be determined by using an indicator.

4. Milk of magnesia is a base. If milk of magnesia is used for an upset stomach, the stomach contents must be acidic; therefore, the pH must be nearer 4 than 9.

A GRAY DAY

OBJECTIVE

State a rule describing the effect of temperature on the direction of flow of a gas.

TEACHING SUGGESTIONS

Preparation

1. Be sure ice cubes will be available on the day needed.

2. Student groups of four are desirable. If sufficient 1000 ml beakers are not available battery jars may be used for the beaker containing the cone. Containers having thin glass walls are preferable, however.

3. If possible, obtain pictures or slides to illustrate smoke pollution.

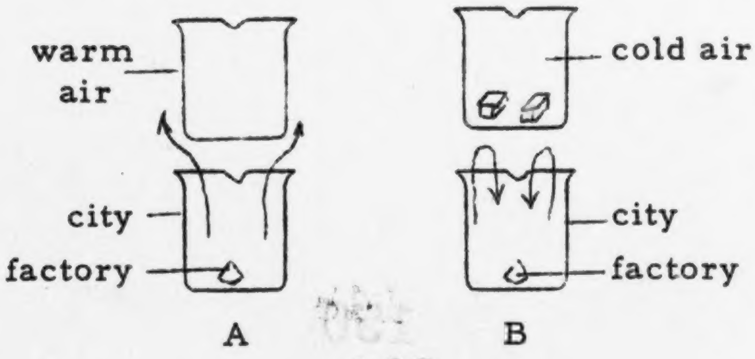
Procedure

1. Demonstrate the following techniques: (a) how to place and light the incense cone; (b) how to rinse the beaker without wetting the outside of it; (c) the distance the warm beaker is to be placed from the beaker in which the cone is burning. Show, by a chalk drawing, how to place lines representing smoke direction.

2. Distribute the materials and have students complete the investigation.

3. During the summarizing discussion encourage students to describe cases of smoke pollution they have observed. Use pictures if possible.

Expected Results



Responses to Interpretation Questions

1. When smoke came into contact with warm air it rose. When it came into contact with cold air, it turned downward.

2. Sources of smoke pollution include the following:

   a. large heating plants, such as those of school buildings

   b. home fireplaces

   c. leaf burning and land clearing

   d. dumps and automobile "graveyards"

   e. planned burning in agricultural and forestry practice

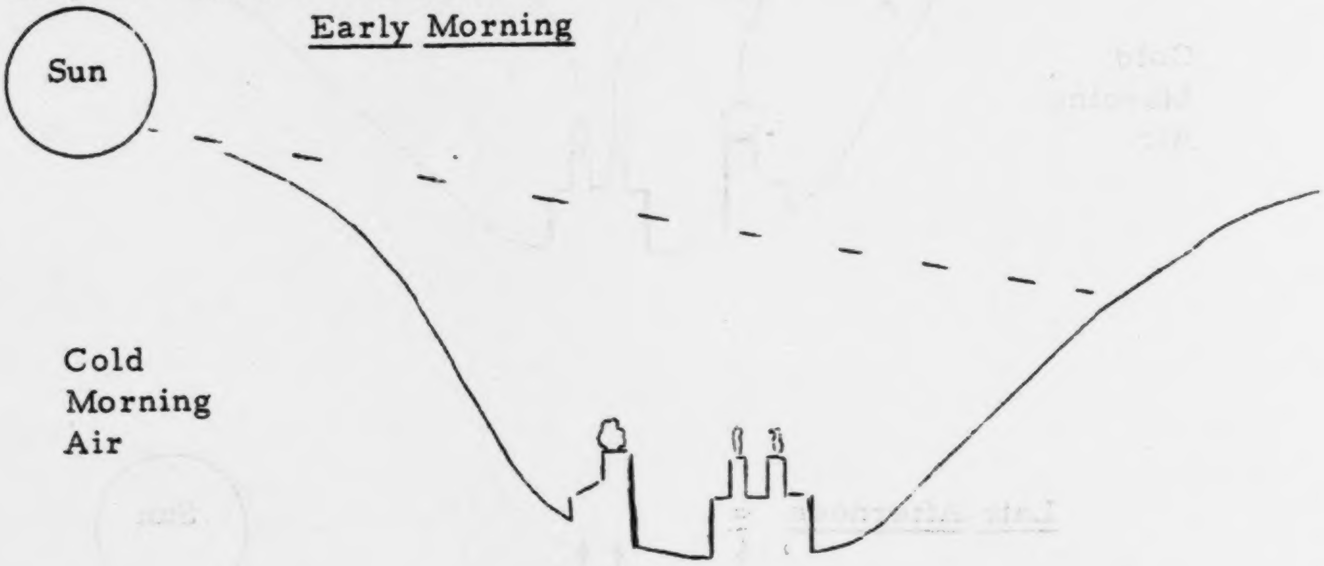
3. Because smoke, in the narrow sense, consists of particles much larger than those of gases, which are molecular, they can be mechanically filtered, in part, and collected by electrostatic charge. Many of the particles represent still burnable fuel and thus increased furnace efficiency can reduce smoke to some extent. Finally, much burning is unnecessary; some substances that are commonly burned can be disposed of by burying or composting.

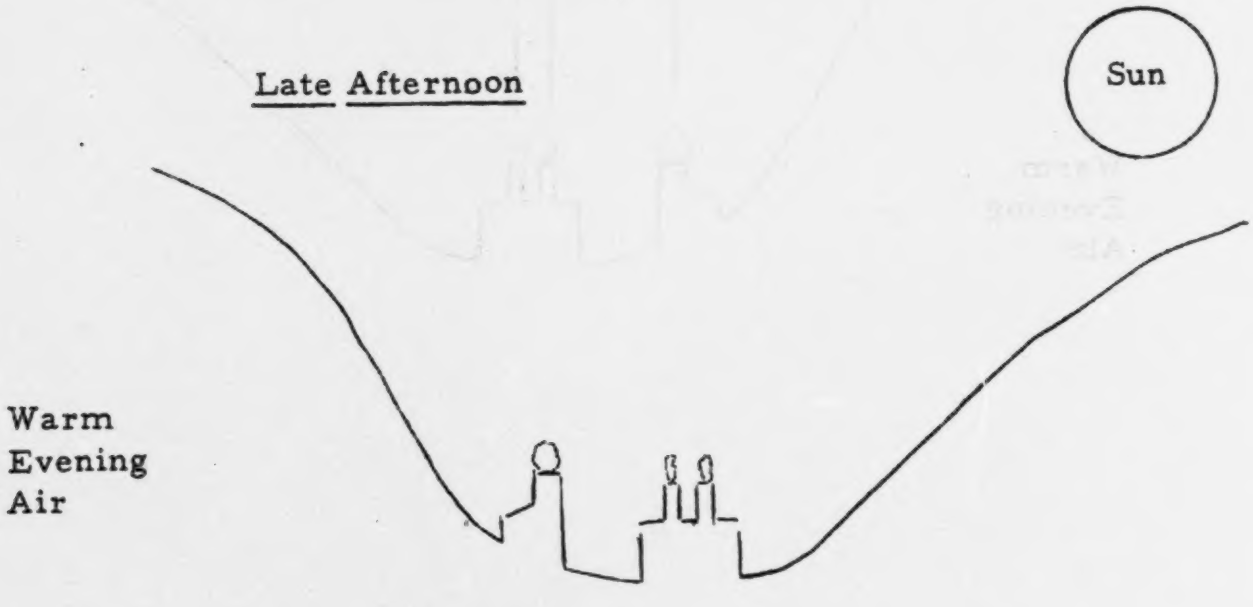
4. A temperature inversion is a source of danger to a city because it does not carry away smoke particles. Instead, the number of smoke particles falling back on a city increases. Smoke in the air settles in human lungs and is a potential source of lung disorders.

Assessment Task

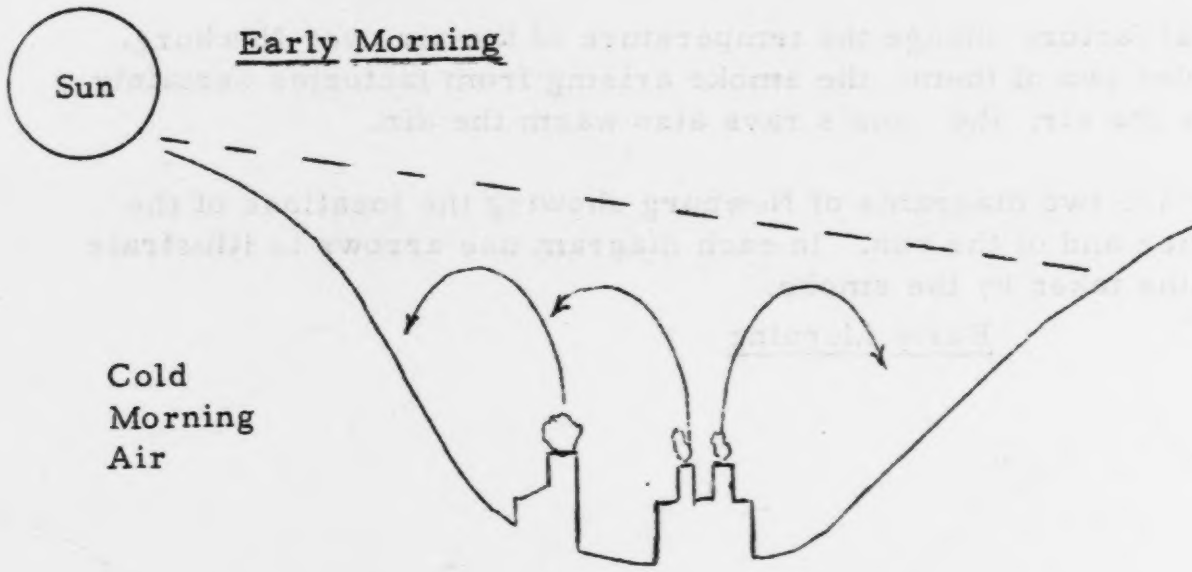
Several factors change the temperature of the air over Newburg. Consider two of them: the smoke arising from factories certainly warms the air; the sun's rays also warm the air.

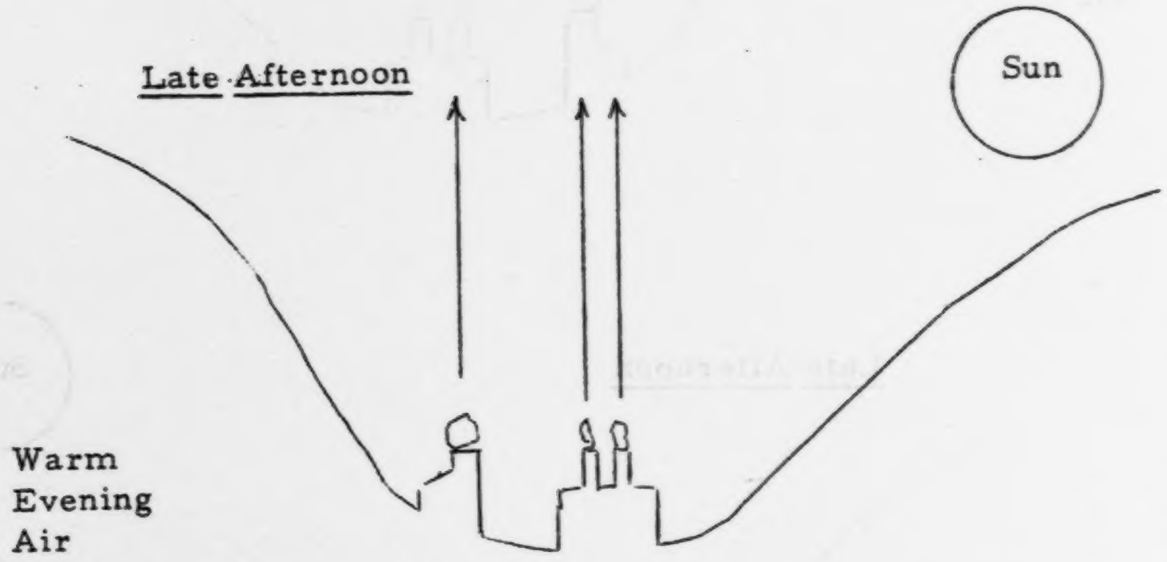
Below are two diagrams of Newburg showing the locations of the factories and of the sun. In each diagram use arrows to illustrate the paths taken by the smoke.


Early Morning
Sun
Cold
Morning
Air


Late Afternoon
Sun
Warm
Evening
Air

Acceptable Response


Early Morning
Sun
Cold
Morning
Air


Late Afternoon
Sun
Warm
Evening
Air

THE GAS CHAMBER

OBJECTIVES

1. **State the rule that carbon monoxide reduces the oxygen-carrying function of blood.**

2. **Demonstrate that sulfur dioxide is injurious to plants and to some non-living things.**

Part A

TEACHING SUGGESTIONS

Procedure

1. Have students read the introduction. Ask the students what they know about the gases mentioned in the introduction. The discussion should be carried just far enough to get students thinking.

2. Have several students read their answers to the interpretation questions.

Responses to Interpretation Questions

1. If one breathes carbon monoxide, hemoglobin molecules pick it up and hold it. These hemoglobin molecules cannot function in carrying oxygen. When most of the hemoglobin molecules are occupied by carbon monoxide, not enough oxygen can be carried by the blood to keep the cells of the body alive.

2. Because carbon monoxide is not released from hemoglobin the effects of carbon monoxide are cumulative. Recovery can come only at the rate that new hemoglobin molecules are produced by the body. In the meantime continuous exposure to small amounts of carbon monoxide can accumulate such a level of inactivated hemoglobin that the energy of the victim can be seriously reduced, since energy-release in the body is dependent upon oxygen supply.

Part B

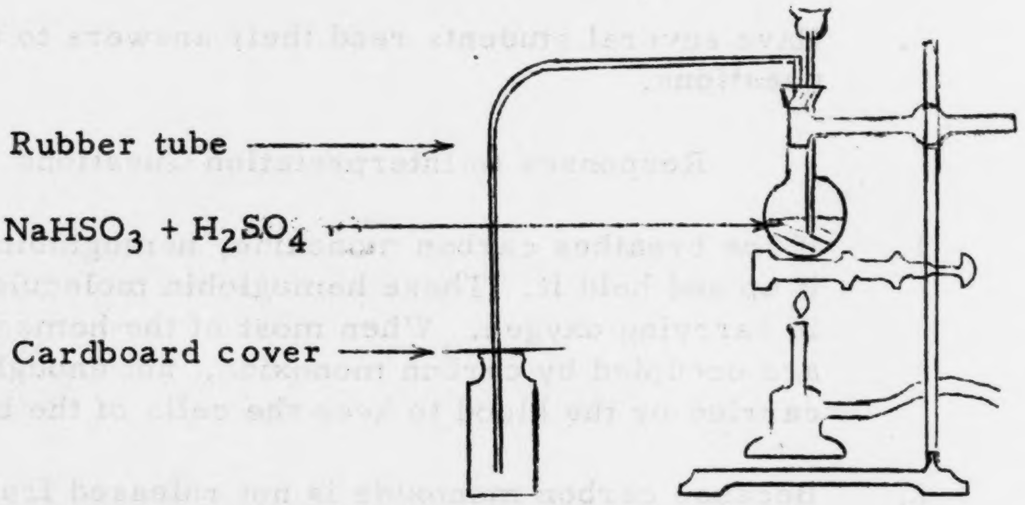
MATERIALS

florence flask, 250 ml
ring stand
ring
clamp
rubber stopper, two-hole
thistle tube
glass tubing, "L" bend
rubber tubing, 70 cm
collecting bottles, 4
ruler, 12", 4
cardboard square with hole
  in it, 10 cm x 10 cm
philodendron, 2 plants
plastic bags, 12" x 12", 2
wooden stakes, 2
sodium bisulfate, 10 g
sulfuric acid, 12 M
litmus paper, blue
bunsen burner
glass plates, 3
colored cotton cloth
nylon
silver teaspoon
pH paper

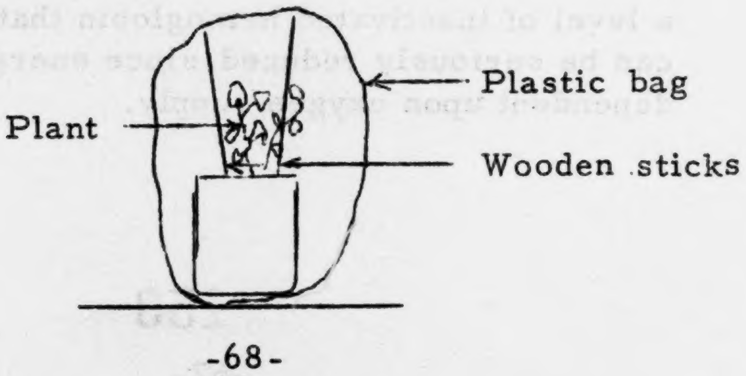
TEACHING SUGGESTIONS

Preparation

1. **Assemble the apparatus for the production of sulfur dioxide as illustrated.**


Rubber tube
$NaHSO_3 + H_2SO_4$
Cardboard cover

2. **Set up two philodendron plants, each one, as illustrated.**


Plastic bag
Plant
Wooden sticks

Procedure

1. Recall that the two gases, carbon monoxide and carbon dioxide, are both odorless and colorless. Pose the questions, "Are all gases colorless? Are all gases odorless?" The students may recall the odors of decay and of rotten eggs without being able to name gases.

2. Open the windows and close the doors. Tell the students why such preparations are made for producing a gas in the chemistry laboratory.

3. Set up the previously assembled apparatus for the production of sulfur dioxide. Place 10 g of $NaHSO_3$ in the flask. DO NOT LIGHT THE BUNSEN BURNER. Pour about 20 ml of concentrated H_2SO_4 into the thistle tube. Collect the gas by upward displacement of air. When the evolution of the gas dies down, gently heat the mixture in the flask with a SMALL flame. The amount of gas evolved can be somewhat controlled by either adding small amounts of sulfuric acid or supplying small amounts of heat. Remove the flame if the gas evolves too vigorously.

   To determine when the bottle is filled with gas, place a moist piece of litmus paper under the cardboard cover. When the litmus paper turns red, remove the bottle, covering the bottle with a glass plate.

4. When two bottles of gas have been collected, pinch the rubber tube. Slide one of the plants close to the tube and insert it under the plastic cover. Release the tube and let the gas generate for at least three minutes. At the end of three minutes pinch the rubber tube again, shutting off the sulfur dioxide. Slide the plant aside.

5. Put the rubber tube into a collecting bottle that has been filled with water. Let the gas bubble through the water for at least five minutes. Cover the bottle with a glass plate and set it aside.

6. Hold a piece of wet, colored cotton cloth and a piece of wet nylon near the open end of the gas tube. Set the cloths aside.

7. Hold a silver teaspoon near the open end of the gas tube until a change is observed. Set the silver objects aside.

8. Pour the water in the thistle tube to stop the reaction and production of gas.

9. Shake the bottle of water into which the sulfur dioxide was bubbled. Have several students carefully smell the liquid.

10. Put a piece of pH paper in tap water and another piece of pH paper into the water to which the sulfur dioxide was bubbled. Put both pieces of pH paper on a clean glass plate. Pass the slide around the room.

11. Pass both the colored cotton cloth and the nylon that have been impregnated with sulfur dioxide around the room.

12. Let several students examine both the teaspoon that has been exposed to the sulfur dioxide gas and the teaspoon that was not exposed.

Expected Results

1. The gas is colorless. The odor is sharp and choking. The odor of the liquid is not like that of the gas. The liquid has a slightly biting odor.

2. a. The pH of tap water is between 6 and 7.
   b. The pH of the water into which sulfur dioxide bubbled may be as low as 3.

3. a. The cloth is bleached.
   b. The nylon has holes where it has been exposed to the gas.

4. The teaspoon that was not held in the sulfur dioxide gas is shiny and silvery. The teaspoon that was held in the sulfur dioxide gas is tarnished, black, and spotted.

Responses to Interpretation Questions

1. Because the bottle was placed so that the opening was up it should be concluded that sulfur dioxide is heavier than air. If the gas had been lighter than air it would have escaped easily from the upward turned bottle.

2. If a gas is heavier than air it will settle near the ground. Gases close to the ground are in contact with living things where, if harmful, they can exert their harmful effects.

3. a. Sulfur dioxide could get into water slowly by dissolving at the surface or, more rapidly, by dissolving in rain drops.

   b. Since sulfur dioxide in water does not have much of an odor or color, it would be difficult to know when the gas is in solution.

   c. Sulfur dioxide dissolved in water gives an acid reaction as shown by the effect on the pH paper.

4. The effects on nylon are due to the formation of acid when sulfur dioxide dissolved in water. The effects on dyes of cloth are more complex and need not be explained in chemical detail.

5. Silverware turns brown when used to eat eggs due to its reaction with sulfur compounds in the yolks.

6. Two plants were used because there is a possibility that a plant might develop leaf spots from causes other than sulfur dioxide. The control does not entirely eliminate this possibility (only an experiment involving large numbers of plants could do this effectively) but it does reduce the probability.

7. Plants produce food and give off oxygen. Both things are needed by animals.

E-17

ONE BIG NEWBURG

OBJECTIVE

Construct statements that define the words biosphere, hydrosphere, atmosphere, and lithosphere.

TEACHING SUGGESTIONS

Preparation

Obtain from the social studies department a large physiographic (not political) globe.

Procedure

1. This is essentially a reading investigation. The introductory paragraphs lead directly to the study of the text and diagram and then on to the interpretation items. With most classes no introductory discussion should be necessary.

2. Following the work by students on an individual basis, considerable time should be spent in class discussion. Since the first three interpretation questions are framed to elicit a variety of responses, some time should be devoted to sharing ideas. These ideas need not be extensively evaluated because there is likely to be a modicum of truth in almost any relationship that a student might suggest. Therefore, strive to obtain responses that will illustrate the range of possibilities. Use the final interpretation question as a summary. A large physiographic globe helps to objectify the whole discussion.

Responses to Interpretation Questions

1. Examples of the effects of water, air, and land on the living systems of the earth are almost infinitely numerous. There may be a tendency for students to think first of disasters as effects. If so, you may need to suggest concrete examples of "It's an ill wind that blows no good." One such example is the 1933 Ocean City hurricane, which destroyed sand-inhabiting animals (and human habitations) in the cutting of an inlet, but opened Assateague Bay to colonization by many marine organisms (and at the same time killed off some strictly brackish ones).

2. No. The hydrologic cycle constantly interchanges water between hydrosphere and atmosphere. The atmosphere mixes with all water surfaces and penetrates into the soils of the lithosphere. Marshes, swamps, and bogs are examples of areas where the hydrosphere and lithosphere overlap; and along the margins of seas the tides twice daily shift boundaries between hydrosphere and lithosphere. Many other examples might be cited by knowledgable students.

3. An example: A hurricane forms in the Atlantic Ocean causing high winds to build huge waves. These waves raise the tides along the Florida coast to exceptionally high levels. The high tides flood the land, drowning terrestrial animals. The floods also wash inland many kinds of shoreline animals. Wind and water together overturn weakened trees and flatten crop plants.

4. Lithosphere: A collective term for all the land area of the earth.

   Hydrosphere: A collective term for all the water surfaces of the earth including lakes, ponds, and rivers as well as oceans, seas, and estuaries.

   Atmosphere: A collective term for all the air that covers the lithosphere and hydrosphere and, in some cases, penetrates the former -- as in soil, caves, and wells.

   Biosphere: A term that denotes not just the sum of all the living things on earth but, more especially, all of these living things among themselves and all the interactions between living things and the total physical environment.

E-18

EARTH: A FINITE SYSTEM

OBJECTIVES

1. Identify some of the finite features of Planet Earth.
2. Construct inferences concerning pollution based on facts gathered from current literature.

TEACHING SUGGESTIONS

Preparation

Obtain a copy of the bibliography, Science for Society, available in the science department of each school. Use this to check sources to which students may be referred at Procedure Step 4.

Procedure

1. Have students read the introduction. Briefly contrast "infinite" and "finite," which as words may look much alike to many students.
2. Have students proceed individually with work on Procedure Steps 1 through 3. Encourage and assist students with calculations.
3. Provide students with suggestions for reference work on pollution statistics. Either arrange a library period for work on this step and on the interpretation, or allow several days for work outside class.
4. In a concluding discussion have several students read their interpretation paragraphs.

Expected Results

Percentage of land area considered arable: 22%.

$$\left[\frac{12,500,000}{57,280,000}\right]$$

Acres of arable land per person in 1970: 2.3 acres.

$$\left[\frac{12,500,000 \times 640}{3,500,000,000} \right]$$

Cubic miles of circulating air per person: about 0.35 cubic miles.

$$\left[\left(\frac{4}{3} \times 3.14 \times (4006)^3\right) - \left(\frac{4}{3} \times 3.14 \times (4000)^3\right) \right] \div 3,500,000,000$$

Estimated world population for 1980: 4,260,000,000 persons.

Acres of arable land per person in 1980: 1.9 acres.

$$\left[\frac{8,000,000,000}{4,260,000,000} \right]$$

E-19

WHO IS GUILTY?

OBJECTIVES

1. **State a rule that all persons contribute to pollution.**

2. **State a rule that all pollution results from the increasing technological development of an expanding populaiton.**

TEACHING SUGGESTIONS

Preparation

For each group prepare a 600 ml beaker containing the following substances approximately 400 ml of water, 10 drops of heavy motor oil, 15 drops of liquid detergent, a small quantity of filamentous algae, 10 ml of 0.1 M hydrochloric acid, and approximately 25 ml of a mixture of sauerkraut and sauerkraut juice.

Procedure

1. Have selected students read aloud the introductory paragraphs. Remind students that now, Newburg = Earth.

2. Distribute the materials. Have students complete the procedure and interpretation questions.

3. The discussion at the end of this investigation should summarize not merely Investigation E-19 but the whole unit. A suitable close is a return to the rhetorical questions at the end of the introduction on Page 84 of the student manual.

Expected Results

Responses will vary for this investigation. Students should, however, be able to identify oil, algae, detergent, acid, and bacteria in the water. Each of the kinds of pollution has several sources as well as reasons for being. All pollutants are, by definition, harmful. Whether the student personally feels harmed is not a matter on which any absolute decision can be made. No pollutant is, again by definition, helpful. A substance that is pollutant under one set of circumstances, may not be under another set of circumstances or in some different quantity. Students however, may think of "helpful" as applying to the process or service that results in the pollution.

Responses to Interpretation Questions

1. With the exception of "nature" any of the sources could be considered as "principal" for one or more pollutants. Answers should conform to the discussions held throughout the unit.

2. With the exception of "unavoidable" any of the reasons could be considered as "principal" for one or more pollutants.

3. All pollution is, by definition, harmful. See discussion under "Expected Results."

4. None of the kinds of pollution is helpful. See discussion under "Expected Results."

5. Each person inevitably produces wastes -- the "raw material" of pollution. Each new person in Newburg thus increased pollution by his mere existence. But Newburg grew not only in population but also in affluence. Each new demand for goods or services not merely added to pollution but compounded it. Therefore the growth of pollution in Newburg -- and the world-- boils down to (1) growth of population and (2) growth of technology.